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A SCENE ALONG THE MOUNTAIN RAILWAY

A TURNOUT IN THE WASI FOREST.

THE BRUNNEN-MORSCHACH ALPINE RAILWAY.

THE BRUNNEN-MORSCHACH ALPINE RAILWAY.

By our BERLIN CORRESPONDENT.

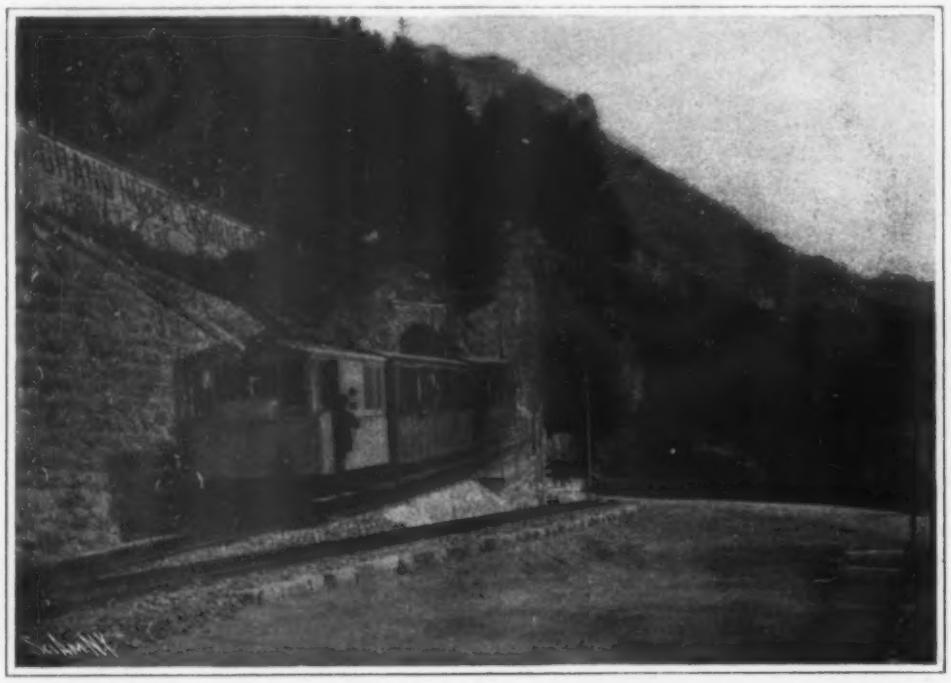
AN interesting mountain railway has been recently opened for operation between Brunnen (on Lake Lucerne) and Morschach. This line is 2,050 meters (1¼ miles) in length, of which 1,160 meters (¾ mile) is situated on a straight line and the rest in curves. The smallest radius of curvature is 80 meters (262 feet) while most curves have radii intermediary between 100 and 150 meters (328 and 492 feet). The average gradient is 12.6 per cent inclusive of the stations, and 14.5 per cent without the latter, the maximum gradient being 17 per cent. Transition curves 400 meters (1,312 feet) in radius have been provided wherever the gradient changes.

The locomotive, the mechanical part of which has been constructed by the Schweizerische Lokomotivfabrik of Winterthur, weighs 10½ tons inclusive of its electrical equipment, and is able to haul a load of 15 tons at a speed of 9 kilometers (5½ miles) per hour on the maximum gradient of 17 per cent.

The electrical equipment has been supplied by Messrs. J. J. Rieter. The electrical current is generated at a pressure of 8,000 volts from the Altdorf power station, being reduced to a working tension of 750 volts by three transformers of the Rieter system in a transformer station situated close to the railway depot.

The electrical locomotives are provided with two 100-horse-power alternating-current motors, and are able to haul two cars with a transporting capacity of eighty passengers in about fifteen minutes from Brunnen to Axenstein. The motors and corresponding starting resistances have been combined in an elegant apparatus with the starting and braking controllers.

The line, after leaving Brunnen, at first traverses a tunnel about 350 meters (1,148 feet) in length, on issuing from which a splendid view is obtained of beautiful Lake Lucerne. After traveling over a long curve on the level of the village of Morschach, the railway on a last gradient reaches the Axenstein Hotel in about five minutes.



TRAIN TRAVELING THROUGH WASIWAND TUNNEL ON A SEVENTEEN PER CENT GRADE.

SOME PRACTICAL EXPERIENCES WITH STEAM TURBINES.*

By C. E. STANTON, Chief Engineer, Union Electric Company, Dubuque, Ia.

STEP-BEARING PUMPS, BAFFLERS, STRAINERS, ETC.

ALL step-bearing water passes first through a "Jewel" water filter, thence through the pumps to the strainer which is contained in the "baffler casting"—thence through the baffler direct to the step bearing. By its passage through the baffler the pressure of the water is reduced, so that (in our case) the actual step-bearing pressure is from 180 pounds to 200 pounds per square inch. All shock or pulsation of the step-bearing pumps is also eliminated by the baffler. As the step pumps and the service pump, which supplies the water used in the step-bearing pumps, are packed with a fibrous packing, we soon found we must keep a record of the safe life of this packing—as if left in until it began to lose its elasticity and get soft, small particles and strings of packing would find their way into the strainers, and would soon plug them, thereby cutting off the water supply to the step. We find that on the step pumps, which pump against a pressure of 400 pounds per square inch, the safe life of the packing is sixty days. On the service pump, against 50 pounds pressure, the safe life of the packing is four months to five months, depending on the condition of the river—whether muddy or not. We find that if dirt or pieces of packing do get into the step-bearing pipe system, it is uncertain when they will find their way into the strainers —it may be hours, days, or weeks. This uncertainty is far from pleasant, because if there is enough loose packing in the system it can at any time plug the strainers, thus cutting off the water supply to the step bearing. With us, all strainers are taken out and cleaned every twenty-four hours.

The hydraulic accumulator, which is connected into and forms a part of the step-bearing piping system, and which acts as a reserve in case of the temporary stoppage of the step-bearing pumps, is tested every twenty-four hours. To test the accumulator, the throttle on the step-bearing pump is closed slightly, as we run the step pumps just fast enough to keep the accumulator up. This slight closing of the pump throttle allows the accumulator to drop slowly. We lower it four or five feet every day. As there are always one or more turbines in operation, and as we carry just pressure enough on our step-bearing pumps (400 pounds) to keep the accumulator raised, if it was not for the test each day, it would always be up and would finally rust fast and would not come down, even if all pressure was removed from the pipe system which holds it up—thus defeating the object for which the accumulator is used. We know by experience that the accumulator will stick, if not tested often. The ram or piston of the accumulator is 9 inches in diameter, and the bored part of the cylinder, which acts as a guide to steady the accumulator when raised, is about 36 inches in length. As this bored part is a close working fit on the ram and the water is always in contact with it, the nicest kind of a rust joint will finally form between the ram and the bored hole around it.

One other precaution, which is usually taken in connection with accumulators for this work, is some kind of signal, usually a steam whistle, which will blow if the accumulator starts to come down. Something of this kind is necessary, as without it, if the step pumps should slow down—and there are many reasons why they should do so—the step pressure might get so low as to be dangerous and injure the step.

STEP BEARINGS.

As the step bearing, with its very thin film of water, under pressure has to support the weight of all the revolving parts of the turbine, wheels, shaft, field, etc., it is a very important part, and cannot be examined too closely while being assembled. Under the bottom half of the step bearing is the adjusting screw; this screw is vertical and in exact alignment with the turbine-shaft center. The end of this screw, on which the step bearing and all the revolving parts of the turbine are carried, must be exactly square with the axis of the screw—a burr or dirt here means trouble, as it will throw the step out of its true alignment. This is also true in regard to the top of the upper step plate and the bottom of the turbine shaft, which rests in a socket or recess in the top of this plate. In the bottom of the turbine shaft are drilled two guides or dowel-pin holes. A key way is also cut across the bottom of the shaft. The guide pins and key are made fast in the top of the upper step-bearing plate, and are an easy fit in the shaft—if all surfaces are clean and all burrs, scratches, etc., removed.

If through any cause the step plate should bind, either from dirt, abrasions, or a bad fit, and it should be forced up in place, the chances are that it would not be square with the shaft. The turbine would then have a tendency to vibrate, and might not run right until this fault was corrected. The bottom step-bearing plate should be an easy fit in the casting which holds it and the adjusting screws in place; it should drop of its own weight into its socket or recess and should not bind or have to be forced to its set. Both step plates should be of exactly the same diameter and should line perfectly. The recess in the plates, from which the step-bearing water is forced out between the faces of these plates, should also be of exactly the same diameter and depth. The edges of the recess should also line perfectly, as if they were not in line a fin might form around one side of the recess, which would cause an unequaled flow of water from the step and have a tendency to cause vibration.

If for any reason it is desired to grind the step bearing in place, it can be done very easily, and without any trouble whatever by gradually closing the stop valve between the step-bearing main pressure pipe and the step bearing. By listening at the step bearing and watching the step-bearing gage while very slowly closing the stop valve, any degree of pressure can be had between the two bearing faces of the step. It should be borne in mind that the greater the speed of the turbine while grinding the step, the faster the faces will grind, and the more damage would be done if the stop valve was closed enough to let the steps together hard.

STEADY BEARING.

Directly above the step bearing is the steady or guide bearing. This is a bronze shell, flanged on one end, lined with babbitt metal, and bored about 0.006 inch larger than the shaft. It is held in place by stud bolts through its flange; these studs are screwed into the bottom of the turbine base. The outside of this sleeve is tapered and fits in a corresponding tapered hole in the base of the turbine. Before this bearing sleeve is put in place, it should be thoroughly cleaned and examined for any rough spots. If it should not seat perfectly all around when in place, it will work loose; screwing up on the nuts will not hold it. We have had two or three loose steady bearings, and in each case the trouble was found to be due to dirt, bruises, or metal chips, which would not allow the bearing to seat properly.

Before leaving the subject of bearings, I want to say that the first turbine started in our plant, and which has done all of its share of the work since (about one year), has the original step bearing and guide sleeve still in place, and apparently as good as ever.

TURBINE PILOT AND MAIN NOZZLE VALVES, ETC.

There are eight main nozzle valves, each with its individual pilot valve, which is electrically controlled. The pilot valves control the action of the main-nozzle valves. On any load within the rated capacity of the turbine, running condensing, five valves are all that will open, leaving three valves which might not open for days at a time. If these valves are left alone they will corrode and stick, and if a heavy overload should come on might not open at all—or if they did open they might stick open. In this case, if a short circuit should open the breakers, the turbines would run away, causing the safeties to act and shutting off the steam supply to the turbines. This would cause considerable more delay in getting current back on the line again. If the main valves are packed too tight, or if the pilot valves leak, the main valves may stick. To obviate these troubles all valves are opened and closed several times each day when starting turbines. As the pilot valves are electrically operated, and as they govern the action of the main-nozzle valves, all that is necessary is to make or break the electrical contact for each valve, which, if kept in proper condition, will open and close promptly.

The close regulation of the turbines was a surprise to some of us who had spent many years in charge of belted and direct-connected engines and generators. It was the original intention to use separate turbines and bus-bars for the commercial lights, but this has not been found necessary. Everything we have—railway, power, and lighting—is on one set of bus-bars. We have no trouble with the regulation of lights or turbines.

A suitable packing for the main-nozzle valves was at first hard to find. We first used a kind of string metallic packing which has proved successful on lower steam pressures, but found it would melt here, as 190 pounds of steam and 150 degs. of superheat were too much for it. We then tried another kind of metallic packing, guaranteed to stand any degree of superheat. This seemed to be made up of small metal chips and graphite, and was supposed to form a well-lubricated metallic ring which would last for months. In use, however, the chips of metal would get under the pilot and main valves, holding them open. All valves had finally to be taken out and cleaned. In cleaning the stuffing boxes all that was found of the packing was a lot of loose metal chips. We now use the best asbestos ring packing we can get, and pack the valves oftener than we expected to with metallic packing.

MIDDLE AND TOP BEARINGS.

The middle bearing is made in halves of cast iron, babbitted and bored out about 0.01 inch larger than the shaft. Extra large oil grooves are cut in both middle and top bearings—they run in a bath of oil, and with a greater circulation of oil through the bearings than would be possible with any other type of bearing with which I am familiar. The top bearing is a cast-iron shell flanged on one end, babbitted and bored about 0.01 inch larger than the shaft; it is clamped in place by bolts through the flange, if it is a solid bearing. We have used both solid and spring bearings for the top and middle bearings. At first all bearings were solid; at present both top and middle bearings are of the spring type. On two turbines the springs have been renewed several times; on one once or twice; on the fourth, or rather the first one supplied with spring bearings, the first bearings put in are still in use—it is about six months since these bearings were first put in.

LUBRICATION.

Gravity oil feed is used on all turbines, and the bear-

* Paper presented at meeting of the Iowa Electrical Association.

ings are so constructed that there can always be a strong circulation of oil through them.

One trouble we had can be best explained by first giving the layout of our gravity oiling system. From the turbines the oil flows by gravity to the oil-cooling and separating tank, then through the oil filter to the suction tank, from which the oil pumps take the oil and pump it into the gravity-oil-feed tank, which is perhaps 25 feet above the turbines. From this tank the oil flows to the turbines, then to the cooling tank, and over its same route through the filter, etc. We have a valve so placed that when closed it cuts the oil off from the gravity-oil tank and puts the full force of the oil pumps on the oil-feed line. This valve proved to be our salvation several times before we learned where our trouble was. With three or four turbines on, the oil would suddenly stop running on the turbines. The only thing left to do was to partially close the valve on the delivery pipe to the gravity-oil-supply tank, putting the oil pump directly on the oil-pipe system, when, of course, the oil had to come if the pumps were in order. It was finally decided that air must trap in the gravity-oil tank, and getting into the oil-feeder pipe line interfere with the flow of oil. This would cause an intermittent flow at certain times, of which we had no means of knowing until we found our supply of oil shut off. That this was right has since been proved by the remedy, which was to vent the top of the tank. We used a ½-inch pipe 4 feet or 5 feet long, with the top bent over in the form of a goose neck.

One point in regard to the step-bearing pumps which was overlooked by me, and should have been mentioned in its proper place, is concerning the water valves. After nine months' service it was noticed that the pumps were running much faster than at first, to do the same amount of work. An examination showed that the water valves and seats were cut quite badly, and nearly all the way around with shallow grooves, mostly, although some spots looked, as far as their shape was concerned, more like corrosion than anything else. We made a tool to true up the seats in place and faced the valves off in a lathe; with a slight grinding with emery dust we had them in good condition again. It was thought that as these valves should open and close positively with each stroke of the pump, they should not cut so quickly, or as badly as they did. Close examination showed that a close hard scale had formed on all valves and seats, and this seemed to hold the valves slightly away from their seats. This wire drawing of the water (if it can be so called) was thought to be the principal cause of the cut valves. We now clean them free from this scale each week.

In conclusion, I will say that this paper is based on the every-day, practical experience of the writer, as encountered in the erection and operation of Curtis four-stage, 500-kilowatt turbines. To cover the subject fully would require more time and space than has been devoted to this article, the purpose of which is to point out some of the things which we have learned in every-day practice.

The steam turbine has upset many of the hard and fast principles of the Corliss engine builder, and is undoubtedly here to stay. The economies and efficiencies of the steam turbine are so pronounced that this type of prime mover is being universally adopted in modern plants for the generation of electrical energy.

ENERGY EXPENDED ON CAR-WHEEL ACCELERATION.

THE energy expended on the angular acceleration of car-wheels forms one of the minor sources of absorption in the propulsion of vehicles. Though it is admittedly a small percentage of the total energy as expended upon linear acceleration, frictional resistances, and the ascent of gradients, it nevertheless reaches a figure in practice which is far from negligible. It is necessarily different for the various types of wheels employed on steam railways and tramways; and any calculation such as the following, based upon particular specimens of wheel is, therefore, only approximately accurate for general application.

The inertia of rotation of a wheel being dependent upon the unchanging moment of inertia of the rotating mass, is amenable to direct calculation. It is quite independent of any experimental or empirical coefficients, and unlike problems in which friction plays a part, is directly subject to established laws. There are two effects by which the inertia of a wheel may be gaged. One is the absorption of energy while accelerating, and the other the increased brake power required for dissipating the kinetic energy stored in the rotating mass. The first of these concerns the design of the motive equipment for the propulsion of the car, and the latter has to be allowed for in the braking apparatus. In connection with a series of brake trials made some thirty years ago upon railway rolling-stock, we had occasion to study the influence of wheel acceleration with a view of ascertaining the proper provision to be made for this unavoidable addition to the inertia of the train. The conclusion arrived at was that, for practical purposes, with the class of wheels in general use, the weights of the tires alone, added to the train weight and considered as partaking of the linear acceleration, would introduce an inertia equivalent to that of the rotating wheels. It is immaterial from which side the problem is faced, as the inertia of the wheel has an equal effect during acceleration and retardation, in both cases opposing the desired change in the velocity of the car.

As the angular and linear speeds of wheels and car are unalterably related when no slipping occurs, the power applied is divided between the two in a ratio which is unchanged by the speed, and is therefore a constant ratio for a car with a given load. The kinetic energy being proportional to ω^2 and v^2, ω and v being the angular and linear velocities, is proportionally increased during acceleration, and diminished correspondingly when the brakes or other retarding forces are operating.

The solution of the problem lies in the correctness of the estimate of I, the moment of inertia, or of the collateral value of ρ, the radius of gyration of the wheel. As the prevailing practice in tramcar wheels favors a somewhat irregular pattern, the calculation of ρ is best attempted by separately considering the tire, spokes, and hub. The selected wheel is 30 inches in diameter, steel-tired, with a cast center of dished spokes. The axle to which it is fitted is 4 inches in diameter, and is reduced to 3½ inches for the journals. The moment of inertia of the entire rotating mass can be found by addition when that of the wheels and axle separately are known. As to the value of I for the axle, which may be taken to be 4 inches in diameter throughout and weighing 250 pounds—

$$I \text{ (axle)} = \frac{250}{32.2} \times \frac{1}{9\times 8} = 0.11 \text{ lb.-ft.}^2$$

$$I \text{ (hub)} = \frac{50}{32.2} \times \frac{1}{3\times 8} = 0.065 \text{ lb.-ft.}^2$$

$$I \text{ (spokes)} = \frac{210}{32.2} \times (0.87)^2 = 4.9 \text{ lb.-ft.}^2$$

$$I \text{ (tire)} = \frac{240}{32.2} \times (1.2)^2 = 10.7 \text{ lb.-ft.}^2$$

With the axle omitted the moment for the two wheels is therefore $2\ (0.065 + 4.9 + 10.7) = 31.33$ pound-feet^2, and ρ is therefore

$$\rho = \sqrt{\frac{31.33 \times 32.2}{1000}} = 1\text{ft. (approx.)}.$$

With the axle included

$$\rho = \sqrt{\frac{31.44 \times 32.2}{1250}} = 0.9 \text{ ft. (approx.)}.$$

The radius of gyration is therefore 80 per cent of the wheel radius when the axle is not included, and 72 per cent when the effect of the axle is added to that of the wheels. If the mass of the rotating parts was disposed about the center in the form of a disk, ρ would be $1 \div \sqrt{2} = 70.7$ per cent of the radius. The preponderating effect of the rim accounts for this difference. The equivalent weight, situated at the tread of the wheel, and therefore moving at the same speed as the car, would be:

w (axle included) $= 1250 \times (0.72)^2 = 648$ lb.
w (axle omitted) $= 1000 \times (0.80)^2 = 640$ lb.

The axle has therefore a very slight effect upon I, and will consequently be omitted in what follows. A given weight at the surface of the axle would have 56 times the influence if placed at the tread of the wheel.

The very serviceable rule of adding the weight of the rim as the equivalent inertia effect has its origin in the approximate equality between $W\rho^2$ and w, where w is the tire weight and ρ the radius of gyration of a wheel of weight W, ρ being expressed as a fraction of unit radius. In view of the many patterns of wheel now in use, the value of ρ would vary, but not very much from the value given, the resulting value for the equivalent weight being $(0.80)^2\ W = 0.64\ W$. This could then be applied when the tire weight was not known. In the foregoing case the tire weighs 240 pounds, or 48 per cent of W, so that for both wheels 480 pounds would be required according to the rule. The difference between this and 640 pounds would be made up by including the rim with the tire. Another lighter 30-inch wheel, which is extensively used, yields the following results: The total weight of the wheel is 340 pounds, of which the calculated weight of tire and rim is 190 pounds, or 56 per cent of W; and as $0.64 \times 340 = 218$, it will be seen that the agreement is very close, considering the difficulty of obtaining a value of ρ which can be applied to all wheels differing slightly in pattern, without being too far out for any single pattern. Wheels which are constructed with a heavy tire secured between two plate-disks by rim bolts have a ratio of tire weight to W not very different from those which have cast centers with chilled or steel tires, for the extra weight in the tire is balanced by the cast rim. As such wheels play a small part in English tramway practice, they need not be considered. The Master Car Builders' Association in the United States have as a standard a 33-inch wheel of this type for heavy traffic.

The equivalent weight to be added to that of a double-deck tramcar, weighing 10 tons loaded, and supported on two maximum traction trucks, fitted with driving wheels and trailers having weights of 340 pounds and 200 pounds respectively, would be $4 \times 0.64\ (340 + 200) = 1{,}380$ pounds, or 6.2 per cent of the total weight. As $w \div W$ increases for diminishing sizes of wheel, the weights of the tires and rims of all the wheels would be approximately $4\ (190 + 120) = 1{,}240$ pounds, or 5.4 per cent of the car weight. When the weights of tire and rim are known, it would be equally within the limits of error to use their sum, which is not very different from 0.64 W. The power required for acceleration of a car, as distinct from that provided for other sources of expenditure, would be generally less than 40 per cent of the total, so that the ratio of the power expended in angular acceleration at the highest speed would be, in the above example, less than 2.5 per cent of the rated motive power equipment of the car, or of the power expended while accelerating near the maximum speed on the ruling gradient.

An electric car has the additional inertia of the armatures; but in considering the power for the propulsion of the car as applied to the axles through reduction gearing, the energy spent in overcoming the armature inertia may properly be regarded as part of the motor losses, and would be considered in the design; but the stored energy would have to be destroyed by the brakes, and would therefore enter into the problem of retardation. By omitting the armature inertia, the application covers motors and trailers alike.—Engineering.

RADIUM: ITS KNOWN MEDICAL VALUE.

THE Medical Record contains an article by Dr. Metzenbaum in which he concludes from a careful and complete *résumé* of the medical literature regarding the use and value of radium, and from a fairly large personal clinical experience covering a period of nearly two years, that the following inferences can be drawn:

1. That lupus responds promptly to the action of radium, and that this result is obtained as readily as with the Finsen light or the X-rays, and that these results seem permanent.

2. That small epitheliomata without glandular involvement heal rapidly under the action of the radium rays.

The epitheliomata may be situated on the face, within the nasal cavity, mouth, pharynx, larynx, vagina, rectum, or bladder, provided the tubes of radium can be brought into intimate contact or close proximity to the diseased area.

Large epitheliomatous areas of the mucous membranes may not be influenced to any marked degree, probably because in large areas the disease is not only superficial but the deeper tissues are involved as well. Epitheliomata on the skin respond far more readily than those of the mucous membranes; this is probably because the skin is kept dry and is not irritated by moisture or friction of the parts. The healing of epithelioma under the action of the radium rays seems to be permanent.

3. The rodent ulcers about the face and head respond better to the action of radium than to any known agent excepting the X-rays and the results are better than those usually obtained by surgical interference.

4. Deep-seated, malignant growths seem beyond the influence of the radium rays, and even when an incision is made into the growth and the tube of radium is inserted into its interior there is then only a histological change in that part of the growth surrounding the tube of radium, as is demonstrated by a microscopical study of the tissue. Even if the radium rays exerted any beneficial influence on truly malignant, deep-seated growths, the fact could not be used to any great advantage in these cases, for the local action would be so pronounced as to cause an ulceration of the skin before it could influence the growth beneath.

5. In certain cases of total blindness, possibly in which some of the fibers of the optic nerve still remain intact, a sensation of light may be noted when a tube of radium of high activity is placed in front of the eye or against the temporal region. But thus far radium has given no beneficial results in the treatment of blindness.

6. When tubes of radium are applied to old scars resulting from healed lupoid ulcers, it causes them to lose their rough and fibrous appearance and renders the area quite smooth and pliable, so it resembles more nearly the healthy tissue.

7. Radium cannot be used like the X-rays to obtain skiagraphs, for it requires at least twelve hours' exposure before the rays penetrate the hand, and then there is not as sharp a differentiation between the tissue as is shown by the X-rays. Again, from such a long-time exposure the skin would be so irritated as to cause it to ulcerate.

8. The beneficial results obtained from radium have been equally good when using tubes of low activity, costing but a few dollars, as when using tubes of very high activity, costing several hundred dollars.

9. Up to the present time radium is to be classed with the Finsen light, X-rays, and surgery in the treatment of lupus, and with surgery and the X-rays in the treatment of rodent ulcer and small epitheliomata.

In machine tool work speed variation is essential, and in a machine driven by an individual motor part of the speed variation must be obtained in the motor itself if efficient speed control is required. The range of speed required in some machines may be quite limited, on account of the particular class of work for which the machine is used, and in such a case the full range of speed could be supplied by the motor. On the other hand, the speed variation required may be so great that it is impossible to supply it all by the motor. Just what range of speed is required in the motor cannot be definitely stated for all conditions. If a total speed range of six to one is required in a machine, it might be advisable under certain conditions to obtain this total range in the motor, but as a general rule the writer believes it would be advisable to use at least two runs of gears when the speed change required exceeds four to one, and that a somewhat better and more efficient design can be obtained when the speed change required in the motor is limited to about three to one

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RESERVOIR, FOUNTAIN, AND STYLOGRAPHIC PENS.—VIII.*

By JAMES P. MAGINNIS, A.M.Inst.C.E., M.Inst.Mech.E.

FOUNTAIN PENS.

IN Fig. 174 (O. Winkler, 1898, 12805), the hollow ink holding pen handle, *A*, is by preference made of glass, and is tapered and curved at the forward end to supply the nib, *N*, which is held in the sliding barrel, *B*. The rubber air ball, *C*, is fitted with a sliding valve, *V*, to control the admission of air, and thus regulate the flow of ink.

The Eagle Pencil Company has designed (1898, 15766), some forms of feed bars, or ink-feeding plugs, as the inventor calls them, for conveying ink from the reservoir to the nib. One of these consists of a tube slotted along the top to receive a tongue, which separates it into two unequal channels.

Fig. 175 (J. Blair, 1898, 17118) shows in part section a reservoir pen in which powdered ink is used. A dry ink cartridge, *C*, is carried in a porous bag, covered at its forward end by a piece of sponge, *S*. Soft water is poured into the reservoir to dissolve the ink powder. Otherwise this pen does not call for any remark.

The pen patented by J. H. Burton (1899, 595) was provided with two ink reservoirs and two writing points. One design shows a feed bar having an ink inlet communicating by means of spiral ducts with the ink supply at the upper side, so as to be in contact with the under side of the nib. Another arrangement shows a somewhat similar feed bar provided with a screw thread engaging with the point section, and having an elongated ink duct which tapers toward the inner end, so that by screwing the piece in or out, the ink supply may be regulated.

In the drawing, Fig. 176 (E. Reisert, 1899, 2000), it is seen that the reservoir supplies ink to the nib through the flexible syphon tube, *A A*. The supply is controlled by pressing on the lever *L*, at intervals, thus closing and opening the passages at the strictures or valves, *V V*. Ink enters at the bottom of the reservoir and travels up the shorter limb of the syphon, and is delivered to the nib at the extremity of the longer limb.

Another pen (R. Cofani, 1899, 10869) had a flexible rubber reservoir. The nib is carried in the holder, to which is pivoted the pressure piece. Ink is contained in the reservoir, and is forced through the supply tube by the action of the pressure piece when the nib is brought in contact with the paper.

In F. C. Edgar's pen (1899, 21195), the nib is held by the barrel above the elongated opening of the ink duct which is supplied from the reservoir. An outer casing protects the whole.

In Fig. 177 (Steinbach & Strache, 1899, 23550) the reservoir, *B*, and front tubular portion, *A*, are screwed on the plug, *C*. The flexible rubber chamber, *F*, supplies the nib with ink, through the beak, *G*, and communicates with the reservoir, *B*, by means of the eccentrically placed channels in the plug, *C*, and the valve, *V*. The nib is so secured, that when in use, its inner surface is free to move and depress the surface of the flexible rubber chamber, *F*.

In Fig. 178 (Salisbury, S. M. & E. C., 1900, 10905) the casing, *A*, is made in two separable parts, connected by a sliding joint, *J*. The ink reservoir, *B*, is made of rubber and is attached to the nipple, *N*, and to the steadying button which loosely fits into an opening, *O*, at the back of the casing, *A*. The ink guide, *D*, consists of a bent wire terminating in a flat paddle, *W*. The nib is held in place by the barrel, *E*.

The feed arrangement of another pen (C. J. Holm, 1900, 11049) consists of a plug, provided with a central duct, in which is inserted a short tube leading to a rubber tube, fitted with a glass mouthpiece, which delivers the ink to the nib.

The peculiarity of the pen shown in Fig. 179 (W. F. Cushman, 1900, 11580) is, that when out of use the nib may be withdrawn into the barrel as shown in the drawing. The nib is carried at one end of the spindle, *B*, sliding through the plug, *C*, and is connected by the screw-plug, *G*, with the sleeve, *F*. When the cap, *H*, is removed from the front of the pen, the sleeve, *F*, and the spindle, *B*, are pushed forward, carrying the nib into position for writing. This appears to be Moore's non-leakable pen.

The ink in F. E. Clarke's pen (1900, 12658) is supplied to the nib through a tube, which may be partly or entirely closed by a tapered wire secured to the screw cap.

In Fig. 180 (H. Grass, 1900, 16558), the nib, *N*, is shown held in slits in the block, *K*, and supplied with ink by the sponge or wad contained in the chamber, *J*. A piston valve, *V*, is provided at the other end with which the rear end of the ink supply tube, *P*, may be closed. Extra wads are kept in the upper end of the cap.

The nib in Fig. 181 (H. Grass, 1900, 17832) is secured in a slit in the plug, *G*. Ink passes from the reservoir, *B*, through the duct, *E*, and is conveyed to the nib by the spiral spring, *L*, inclosed in the chamber, *J*. An opening is provided in the outer metallic case, so that the interior flexible rubber reservoir may be compressed slightly by the finger in writing.

In H. W. Dixon's pen (1900, 23567), the ink is sucked into the reservoir by turning the head, until the lower end of the inner tube is unscrewed from the plug. The inner tube may then be slowly withdrawn, and ink thus sucked upward. When the reservoir is charged sufficiently, further withdrawal of the tube is prevented by wire stops, it is then inverted, and the tube may be moved back into the other extreme position.

In Fig. 182 (F. C. Brown, 1898, 8540), the nib, *P*, is held between the upper and lower tongues of the feed bar, *H*, which terminates in the form of a rod. A sleeve nut, *S*, is attached to the cap, *K*, and may be rotated by it. A pin in the rod, *H*, fits in the groove of the nut, *S*, and as the latter is rotated causes the rod, *H*, to travel in an upward or downward direction, as desired. The nib may thus be drawn within the nozzle, and the cap provided may then be screwed on at *X*, making a non-leakable joint.

Fig. 183 shows the forward end of the triple feed-bar now used in connection with the pen, known as the Caw pen, and issued by Messrs. Eyre & Spottiswoode.

Having now indicated the most important features of many of the fountain pens which have from time to time been invented, I will briefly describe some of those of more modern date or at present in use.

The "Sackett" pen shown in Fig. 184 has already been described in detail. This drawing, however, shows the tongue in plan, and also a cross section of the grooved feed-bar. No further description is perhaps necessary.

The "Quill" pen, Fig. 185, of Mr. W. S. Hicks, whose name is well known as the maker of pocket pencils, is something like the "Wirt" (described later) as regards its feed-bar. This is, however, about treble the length of that of the Wirt pen, and terminates in a wavy form, as shown, and similar in this respect to the Sackett pen of 1886. The undulations of the feed bar are so designed that they equal the internal diameter of the barrel or ink reservoir, so that in re-filling the pen with ink it is not necessary to withdraw the feed-bar completely, as the elasticity of the latter, acting against the barrel, holds it in a suitable position to permit of re-filling.

On reference to the drawing, Fig. 186 (De la Rue's "Pelican" safety fountain pen), it will be seen that the holder consists of three parts, viz.: The pen carrier, *F*, the body, *C*, and the plug, *H*. The body, *C*, is so constructed that it may be screwed into the pen carrier, *F*, until it closes the two apertures, *A* and *B*. By the reverse process the apertures are opened as shown in the drawing. The lower aperture, *A*, communicates with the duct, *G*, whereby the ink is led along the upper surface of the nib to the point, *E*. The duct, *B*, at the same time admits an equal volume of air to replace the ink as used in process of writing. The plug, *H*, is unscrewed for the purpose of recharging the holder with ink, before doing which the apertures, *A* and *B*, must, of course, be closed as already described. By the courtesy and kindness of Mr. Evelyn De la Rue, I have had the privilege of seeing these pens made, and it gave me much pleasure to notice the accuracy with which the various parts are made and fitted together, and the great care exercised in turning out an implement as perfect as possible.

This pen (the "Lacon" pen, Fig. 187) has already been described, and calls for no further comment.

The feed bar of the "Dragon" pen, shown in Fig. 188) is partly cylindrical with a V-shaped groove extending along its under side. The front end is prolonged in the form of a tongue which rests on the upper surface of the nib. The pen from which this drawing was made was submitted to me by the American Pencil Company. It has a tapering cap which is perhaps an advantage, as it tends to keep a better balance when writing.

The feed bar of the "Camel" pen, of Messrs. Ormiston & Glass, in Fig. 189, consists of a single rod fitting into a point section. It has grooves and passages for ink and air as shown in the drawing. The front end terminates in a single top feed tongue, and a slit extending backward about half way for the reception of the nib.

Fig. 190 (the "Fleet" pen) shows an exceedingly low-priced fountain pen, the specimen in my collection

* Journal of the Society of Arts.

Fig. 174.

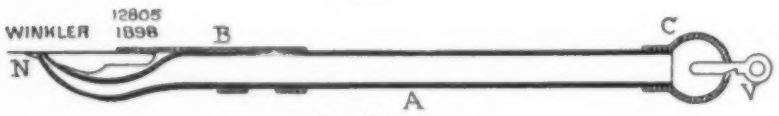


Fig. 175.

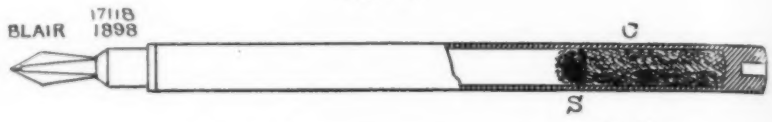


Fig. 176.

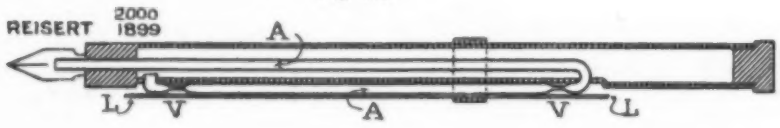


Fig. 177.

Fig. 178.

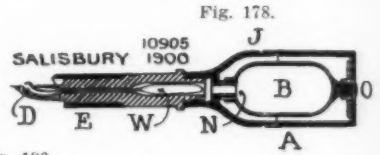


Fig. 179.

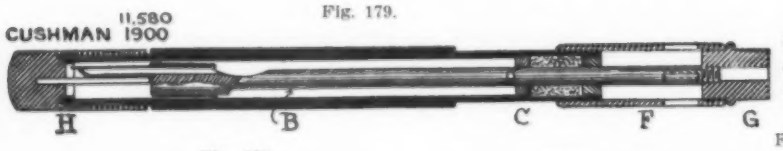


Fig. 180.

Fig. 181.

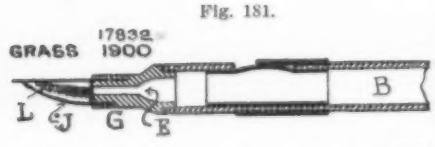


Fig. 182.

Fig. 183.

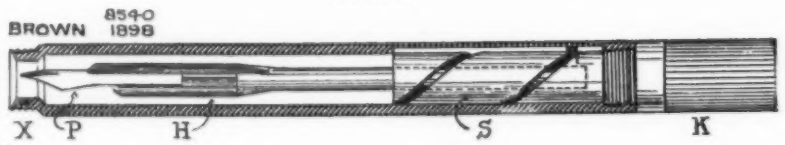


Fig. 184.

Fig. 185.

Fig. 186.

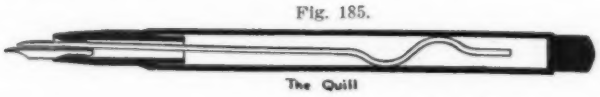


Fig. 187.

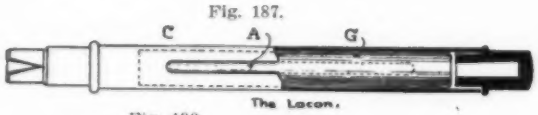


Fig. 188.

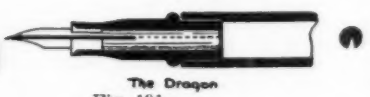
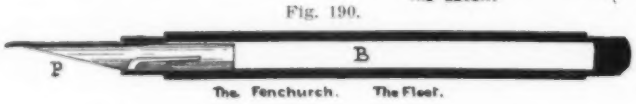


Fig. 189.

Fig. 190.

Fig. 191.



costing the modest sum of 6½d. It consists of a barrel or ink reservoir, *B*, and a plug, *P*, which almost fills the neck of the barrel. This plug is circular in section, cut away diagonally at the front end, to a point. A saw-cut groove extends longitudinally along its upper side, nearly to the point, while underneath is a cut or gash, which almost divides the plug into two parts. This latter acts mechanically as a spring, so that when the nib and plug are together placed in the barrel, both are held firmly in position. It is intended that almost any suitable form of metal or steel nib may be used, and not necessarily a gold one.

The "Lincoln" pen shown in Fig. 191 has nothing very special to speak of. It has a simple form of single undertype feed, and the pen takes its name from that of one of the most popular of the United States Presidents. I am informed by Messrs. Deverell, Sharpe & Gibson that Messrs. Perry & Co. claim the name, "Lincoln," as applied to pens of all descriptions, so that the "Lincoln" fountain pen is now known as the "Devarson," a name built up of syllables from the names of the members of the firm. Since writing the foregoing, I have tested the "Devarson" pen, and I can vouch for its excellence. The feed is simple, and effective.

Fig. 192 shows the business end of the "Stafford" pen. Like Fig. 191, and many other pens of very high excellence, it is produced in the United States. Its feed bar is a combination of that of the Waterman pen of 1884, in that it has parallel saw-cut ducts extending along its upper half, and it also resembles the feed bar of Prince's pen of 1855, in that it has a thin vulcanite tongue, a plan of which is shown on the drawing, which lies along the ink duct and vibrates with the action of the nib. The feed is very satisfactory, and I like the pen on account of its capacity for ink. Although I have fitted it with a "Swan" nib, I have found it very reliable.

Fig. 193 shows the point section of the "Swallow" pen, and just enough of the feed arrangement is visible to show that it bears a very striking resemblance to that of the Swan pen of 1895. Imitation is said to be the most sincere form of flattery, and probably the maker of the Swallow pen knows a good thing when he sees it.

In Fig. 194 is shown the point of the "Parker" pen, known as the "lucky curve" pen. A saw cut commences at the rear end of the feed bar, almost dividing it in two parts, and then traverses the upper surface, reaching nearly to the point, where it disappears. Air is admitted through a small hole, entering at the under side, as indicated by the arrow, and passes upward to the saw cut.

The "Swan" pen (Fig. 195) is perhaps a household word. There are those who think, or perhaps they do not think, that the name "Remington" covers all typewriting machines that ever were invented. Some firmly think that all hand cameras are Kodaks, and there are also many who no doubt think that "Swan" is a sort of generic name for fountain pens. Be that as it may, Messrs. Mabie, Todd & Bard have not been wanting in energy and painstaking ability to make the fountain pen popular. Their pens are known, and deservedly so, throughout the civilized world. As a matter of fact I wrote these words with one of their gold nibs purchased thousands of miles away, and used for many years in the Friendly Islands. It now glides smoothly and silently along, although it is adapted to a different holder and feed arrangement to that for which it was originally intended. The feed arrangement of the "Swan" consists of two parts. The feed bar is of the double type, that is to say, the bar is divided for about one-half its entire length into two tongues, between which the gold nib is placed so that there is a tongue on the top of the nib which reaches to within a short distance of its point, and a second tongue lies snugly on the underside of the nib, being about 1/8 or 3/16 of an inch shorter than the upper one. This feed bar being originally tubular is grooved longitudinally along its inner surface forming ducts whereby the ink is led to the nib. Besides the feed bar proper there is a twisted silver wire, the polished surface of which repels the ink, and in doing so provides a means of conducting air to the ink chamber, thereby completing the circulation. Without unduly giving prominence to the "Swan" pens, I would say that I have carried one of them for some time, and I have always found it reliable. It is always ready to write as soon as it touches paper, and it has never yet emptied its contents where not required. Mr. Watts, the London manager of this firm, has rendered me much service in connection with my lectures, in showing me many pens now obsolete, while on the other hand I have had pleasure in showing to him others, of the existence of which he had not previously known.

In Waterman's "Ideal" fountain pen (Fig. 196) the great charm lies in its simplicity. In every fountain pen the feed is the all-important detail that makes or mars its success. The feed of the Ideal is the essence of simplicity. It is strong, and unlikely to get out of order, and it insures a copious supply of ink at the business end of the nib, without fear of delivering it too quickly. The drawing shows one of these pens in section. It will be noted that the feed bar, *B*, contains a grooved duct or passage, extending almost to its entire length. This duct is about one-sixteenth of an inch wide, and along the bottom of the duct are parallel saw cuts by which the capillary action is secured. Cross sections of the feed bar were shown earlier. A later improvement has been effected. On either side of the duct, pockets or recesses are formed, which were not shown on the previous drawings. These pockets are designed to collect any surplus ink, and hold it in readiness to meet the requirements of the nib. This form of feed allows practically the whole of the barrel to be at disposal as an ink reservoir, as there are no internal projections. It is stated by the manufacturers that their pens will hold sufficient ink to write from 16,000 to 30,000 words. I have given two of these pens a severe trial, and the only fault I have to find with them is that they will not write without ink. Mr. Symonds, of Messrs. Mordan & Co., as well as Mr. Sloan, of Messrs. Hardmuth & Co., have been good enough to give me many facilities for testing these pens.

In Fig. 197 is a drawing of the "Hearson" pen, consisting of three parts, viz., the reservoir, the point section, and the nib of barrel type. It will be remembered that this has already been described in detail, as having a steel barrel nib enveloped in an India-rubber casing.

Fig. 198 shows the feed bar of the "Neptune" fountain pen. It will be seen to consist of a tube having a longitudinal slice cut from the rear end, while the other or front end is formed into two blades or fingers, one of which lies above the nib, and the other below it, in close contact. Sometimes there is only one finger, or, in other words, a single feed. I need hardly call attention to the fact that there are three different kinds of feed used in fountain pens, viz.: Single feed, top; single feed, bottom; double feed, top and bottom; one or other of which is adopted.

Fig. 199 is the "Wirt" pen (P. E. Wirt, 1885, 1496). This is a pen of the single feed type. The feed bar, too, is on the top of the nib. The feed bar consists of a single blade of vulcanite, about 2½ inches long, reaching nearly to the point of the nib, and extending backward into the ink reservoir, the rear part being formed somewhat like a paddle or oar. Air finds its way under the nib, and bubbles upward through the body of ink, while the ink by capillary force is fed along the bar. In general appearance the Wirt pen is very like other fountain pens. I had the good fortune to become possessed of one of these pens, which I used regularly for nine or ten years, and it is still as good as new. The drawing now shown is taken from the pen referred to, and the manufacturers have recently afforded me an opportunity to test a more modern pen, which I find equally efficient.

Moore's "Non-leakable" pen (Fig. 200) is another of those pens designed to prevent leakage when carried in the pocket, and it fully justifies what is thus claimed for it. The pen, or nib, can be drawn within the barrel by means of the slide or thimble, *S*, attached to the rear end of the elongated feed, *F*, which passes through the end of the barrel, and is screwed into the plug, *P*. A stop pin, *A*, prevents too much movement. The cap is provided with a screw thread, by which it can be securely screwed on the open end of the barrel, thus insuring a sealed joint. A projecting rod, *C*, in the cap prevents any injury to the point of the nib when the cap is screwed down, as it abuts against the plug, *P*, and prevents any movement of the pen. I have given four of these pens a severe trial, and cannot speak too highly of them. They appear to be absolutely non-leakable when closed, no matter in what position they may be carried, and under all conditions they are perfect of their kind.

The "Horton" pen, shown in section in Fig. 201, is very similar to the following pen. It will be noted, however, that the sleeve nut has a double groove or thread, and also that there is a movable point section, but the movements are otherwise identical.

The distinctive feature of "Caw's Safety" fountain pen (Fig. 202) is the method whereby the pen-point is made to recede into the ink holder. The illustration shows clearly how this is effected. It will be seen that the feed bar, *F*, into which is fixed the nib, is elongated, and its rear end enters a cylinder having a spiral groove cut in it. A pin attached to the feed bar passes through the spiral groove, and is free to slide up or down in a straight groove cut in the barrel of the pen. The cylinder, *C*, is attached to the milled portion, *M*, of the pen, and on turning *M*, the cylinder, *C*, revolves with it, causing the feed bar, *F*, to travel, and the nib is thus propelled or withdrawn into the reservoir of ink; if the latter is desired, then the cap is screwed on at *K*, preventing the outflow of ink in whatever position the pen may be carried. It will be evident that when the nib is propelled, the feed bar, enlarged at that point, closes up the restricted aperture of the barrel, so that no ink can escape other than is required to supply the nib. I have tested one of these pens, which Messrs. Eyre & Spottiswoode kindly sent for my inspection a few days ago, and I find that it leaves nothing to be desired.

The "Swift" pen (Fig. 203) belongs to that class which makes special provision against risk of leakage, when out of use or when lying in a horizontal position. This end is accomplished by means of the valve, *V*, operated from the upper end, *E*, of the pen, which when screwed down, closes the ink-passage. The feed is of a very simple description, as may be seen. The ink passes along the tapering channel to the under side of the pen, *I*, air being admitted at the opening, *A*. The nib is fixed in the slit, *N*, provided for it. It appears to be identical with W. T. Shaw's patent of 1897, already described and illustrated.

An early form of pen (Fig. 204) of the self-filling type is the "Automatic." The specimen I am about

Fig. 192.

Fig. 193.

Fig. 194.

Fig. 195.

Fig. 196.

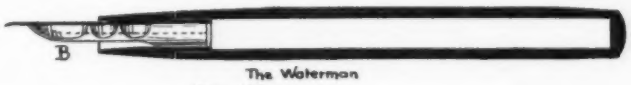


Fig. 197.

Fig. 198.

Fig. 199.

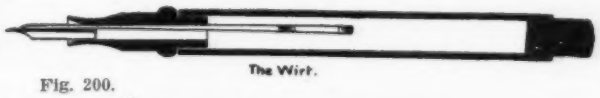


Fig. 200.

Fig. 201.

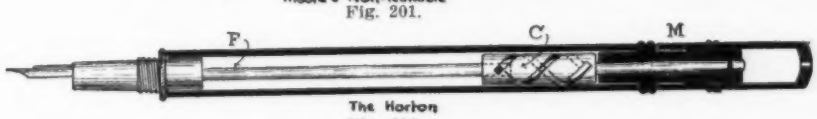


Fig. 202.

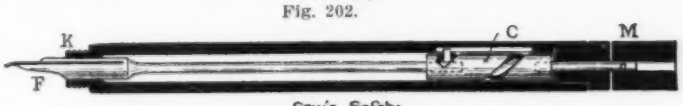


Fig. 203.

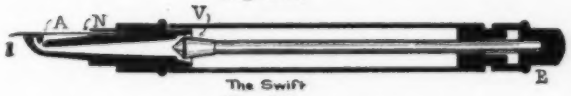


Fig. 204.

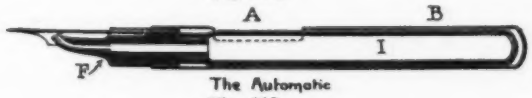


Fig. 205.

to describe has been in my possession since about 1878. It is constructed entirely of metal with the exception of the ink container, *I*, which is a flexible rubber tube closed at one end, and attached to the feed point, *F*, at the other end. In the casing, *B*, is an opening, *A*, placed in such a position that the thumb may readily be placed upon it so as to create a pressure on the ink container, *I*, and thus force a supply of ink to the nib as required. To fill the pen, the casing, *B*, is removed, the container is compressed to expel all the air, and placing the point in an ink bottle, the container is allowed to expand when it becomes charged with ink. A cap is provided for the protection of the nib. This pen differs in one respect from that of Michell, in that the ink is delivered underneath the nib, whereas it will be remembered, perhaps, that in Michell's patent, the ink was delivered on the back of the nib.

The "Conklin" pen, shown in Fig. 205, is an improved form of the "Automatic" just described. Its method of refilling is precisely the same, but a pressure bar, *P*, is provided, which extends practically the entire length of the flexible ink container, *I*. When the thumb-piece, *T*, is pressed down the container, *I*, is flattened, and thus it is emptied of air. The casing of the pen is of vulcanite, and the point section; *S*, is fitted into it without any screw thread, as an ink-tight joint is unnecessary. The ink-container may be readily and cheaply renewed when necessary, and for those who like a self-filling pen this one ought to find favor. The method of filling will be shown presently.

(To be continued.)

CEMENT MATERIALS AND INDUSTRY OF THE UNITED STATES.*

By EDWIN C. ECKEL.

DEFINITION OF PORTLAND, NATURAL, AND PUZZOLAN CEMENTS.

BEFORE taking up the subject of the materials and manufacture of cements, it is advisable to define the four great classes which are included in the group of "hydraulic cements," as that term is used by the engineer. The relationship of the various cementing materials† can be concisely expressed as in the following diagram:

Nonhydraulic cements	Plaster of Paris, cement plaster, Keene's cement, etc.
	Common lime.
Hydraulic cements	Hydraulic lime.
	Natural cements.
	Portland cements.
	Puzzolan cements.

Nonhydraulic Cements.—Nonhydraulic cements do not have the property of "setting" or hardening under water. They are made by burning, at a comparatively low temperature, either gypsum or pure limestone. The products obtained by burning gypsum are marketed as "plaster of Paris," "cement plaster," "Keene's cement," etc., according to details in the process of manufacture. The product of burning limestone is common lime.

Hydraulic Cements.—The hydraulic cements are those which set when used under water, though the different kinds differ greatly in the extent to which they possess this property, which is due to the formation during manufacture of compounds of lime with silica, alumina, and iron oxide.

On heating a pure limestone ($CaCO_3$) containing less than, say, 10 per cent of silica, alumina, and iron oxide together, its carbon dioxide (CO_2) is driven off, leaving more or less pure calcium oxide (CaO—quicklime or common lime). If the limestone contains much silica, alumina, or iron oxide, the result is quite different.

Natural Cements.—Natural cements are produced by burning a naturally impure limestone, containing from 15 to 40 per cent of silica, alumina, and iron oxide, at a comparatively low temperature, about that of ordinary lime burning. The operation can therefore be carried on in a kiln closely resembling an ordinary lime kiln. During the burning the carbon dioxide of the limestone is almost entirely driven off, and the lime combines with the silica, alumina, and iron oxide, forming a mass containing silicates, aluminates, and ferrites of lime. If the original limestone contained much magnesium carbonate the burned rock will contain a corresponding amount of magnesia.

The burned mass will not slake if water be added. It is necessary, therefore, to grind it rather fine. After grinding, if the resulting powder (natural cement) be mixed with water it will harden rapidly. This hardening or setting will also take place under water. Natural cements differ from ordinary limes in two noticeable ways:

(1) The burned mass does not slake on the addition of water.

(2) The powder has hydraulic properties, i. e., if properly prepared, it will set under water.

Natural cements differ from Portland cements in the following important particulars:

(1) Natural cements are not made from carefully prepared and finely ground artificial mixtures, but from natural rock.

(2) Natural cements are burned at a lower temperature than Portland, the mass in the kiln never being heated high enough to even approach the fusing or clinkering point.

(3) Natural cements, after burning and grinding, are usually yellow to brown in color and light in weight, having a specific gravity of 2.7 to 3.1, while Portland cement is commonly blue to gray in color and heavier, its specific gravity ranging from 3 to 3.2.

(4) Natural cements set more rapidly than Portland cement, but do not attain so high tensile strength.

(5) Portland cement is a definite product, its percentages of lime, silica, alumina, and iron oxide varying only between narrow limits, while brands of natural cements vary greatly in composition.

Portland Cement.—Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, alumina, and iron oxide in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale, in which case the mixture should contain about three parts of the lime carbonate to one part of the clayey materials. The burning takes place at a high temperature, approaching 3,000 deg. F., and must therefore be carried on in kilns of special design and lining. During the burning, combination of the lime with silica, alumina, and iron oxide takes place. The product of the burning is a semi-fused mass called "clinker," which consists of silicates, aluminates, and ferrites of lime in certain fairly definite proportions. This clinker must be finely ground. After such grinding, the powder (Portland cement) will set under water.

Puzzolan Cements.—The cementing materials included under this name are made by mixing powdered slaked lime with either a volcanic ash or a blast-furnace slag. The product is, therefore, simply a mechanical mixture of two ingredients, as the mixture is not burned at any stage of the process. After mixing, the mixture is finely ground. The resulting powder (puzzolan cement) will set under water.

Puzzolan cements are usually light bluish, and of lower specific gravity and less tensile strength than Portland cement. They are better adapted to use under water than in air, as is explained later.

MATERIALS AND MANUFACTURE OF PORTLAND CEMENT.

Definition of Portland Cement.

Portland cement is an artificial product, obtained by finely pulverizing the clinker produced by burning to semi-fusion an intimate mixture of finely ground calcareous and argillaceous material, this mixture consisting, approximately, of one part of silica and alumina to three parts of carbonate of lime (or an equivalent amount of lime).

Composition and Constitution.

The ideal Portland cement, toward which cements as actually made tend in composition, would consist exclusively of tricalcic silicate, and would be therefore composed entirely of lime and silica in the following proportions: Lime (CaO), 73.6 per cent; silica (SiO_2), 26.4 per cent.

Such an ideal cement, however, can not be manufactured under present commercial conditions, for the heat required to clinker such a mixture can not be attained in any working kiln.

In order to prepare Portland cement in actual practice, therefore, it is necessary that some other ingredient or ingredients be present to serve as a flux in aiding the combination of the lime and silica, and such aid is afforded by the presence of alumina and iron oxide.

Alumina (Al_2O_3) and iron oxide (Fe_2O_3), when present in noticeable percentages, serve to reduce the temperature at which combination of the lime and silica (to form $3CaO.SiO_2$) takes place; and this clinkering temperature becomes further and further lowered as the percentages of alumina and iron are increased. The strength and value of the product, however, also decrease as the alumina and iron increase; so that in actual practice it is necessary to strike a balance between the advantage of low clinkering temperature and the disadvantage of weak cement, and thus to determine how much alumina and iron should be used in the mixture.

It is generally considered that whatever alumina is present in the cement is combined with part of the lime to form the compound $2CaO.SiO_2$—dicalcic aluminate. It is also held by some, but this fact is somewhat less firmly established than the last, that the iron present is combined with the lime to form the compound $2CaO.Fe_2O_3$. For the purposes of the present paper it will be sufficient to say that, in the relatively small percentages in which iron occurs in Portland cement, it may for convenience be considered as equivalent to alumina in its action, and the two may be calculated together.

Raw Materials for Portland Cement.

For the purposes of the present section it will be sufficiently accurate to consider that a Portland-cement mixture, when ready for burning, will contain about 75 per cent of lime carbonate ($CaCO_3$) and 20 per cent of silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3) together, the remaining 5 per cent including any magnesium carbonate, sulphur, and alkalies that may be present.

The essential elements which enter into this mixture—lime, silica, alumina, and iron—are all abundantly and widely distributed in nature, occurring in different forms in many kinds of rocks. It can therefore readily be seen that, theoretically, a satisfactory Portland-cement mixture could be prepared by combining, in an almost infinite number of ways and proportions, many kinds of raw material.

The almost infinite number of raw materials which are theoretically available are, however, reduced to a very few under existing commercial conditions.

The raw material which furnishes the lime is usually natural—a limestone, chalk, or marl—but occasionally it is an artificial product, such as the chemically precipitated lime carbonate which results as waste from alkali manufacture. The silica, alumina, and iron oxide of the mixture are usually derived from clays, shales, or slates; but in a few plants blast-furnace slag is used as the silica-aluminous ingredient in the manufacture of true Portland cement.

The various combinations of raw materials which are at present used in the United States in the manufacture of Portland cement may be grouped under six heads: (1) Argillaceous limestone (cement rock) and pure limestone; (2) pure hard limestone and clay or shale; (3) soft chalky limestone and clay; (4) marl and clay; (5) alkali waste and clay; (6) slag and limestone.

Value of Deposits of Cement Materials.

The determination of the possible value for Portland cement manufacture of a deposit of raw material is a complex problem, depending upon a number of distinct factors, the more important of which are as follows: (1) Chemical composition, (2) physical character, (3) amount available, (4) location with respect to transportation routes, (5) location with respect to fuel supplies, (6) location with respect to markets.

Ignorance of the respective importance of these factors frequently leads to an overestimate of the value of a deposit of raw material. Their effects may be briefly stated, as follows:

(1) Chemical Composition.—The raw material must be of correct chemical composition for use as a cement material. This implies that the material, if a limestone, must contain as small a percentage as possible of magnesium carbonate. Under present conditions, 5 or 6 per cent is the maximum permissible. Free silica, in the form of chert, flint, or sand, must be absent, or present only in small quantity—say 1 per cent or less. If the limestone is a clayey limestone, or "cement rock," the proportion between its silica and its alumina and iron should fall within the limits

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3} > 2 : \frac{SiO_2}{Al_2O_3 + Fe_2O_3} < 3.5.$$

A clay or shale should satisfy the above equation, and should be free from sand, gravel, etc. Alkalies and sulphates should, if present, not exceed 3 per cent.

(2) Physical Character.—Economy in excavation and crushing requires that the raw materials should be as soft and as dry as possible.

(3) Amount Available.—A Portland cement plant running on dry raw materials, such as a mixture of limestone and shale, will use approximately 20,000 tons of raw material a year per kiln. Of this about 15,000 tons are limestone and 5,000 tons shale. Assuming that the limestone weighs 160 pounds per cubic foot, which is a fair average weight, each kiln in the plant will require about 190,000 cubic feet of limestone a year. As the shale or clay may be assumed to contain considerable water, a cubic foot will probably contain not over 125 pounds of dry material, so that each kiln will also require about 80,000 cubic feet of shale or clay.

A cement plant is an expensive undertaking, and it would be folly to locate a plant with less than a twenty years' supply of raw material in sight. In order to justify the erection of a cement plant, there must be in sight at least 3,800,000 cubic feet of limestone and 1,600,000 cubic feet of clay or shale for each kiln.

(4) Location with Respect to Transportation Routes.—Portland cement is for its value a bulky product, and is therefore much influenced by transportation routes. To locate a plant on only one railroad, unless the railroad officials are financially connected with the cement plant, is simply to invite disaster. At least two transportation routes should be available, and it is best of all if one of these be a good water route.

(5) Location with Respect to Fuel Supplies.—Every barrel (380 pounds) of Portland cement marketed implies that at least 200 to 300 pounds of coal have been used in the power plant and the kilns. In other words, each kiln in the plant will, with its corresponding crushing machinery, use up from 6,000 to 9,000 tons of coal a year. The item of fuel cost is therefore highly important, for in the average plant about 30 to 40 per cent of the total cost of the cement will be chargeable to coal supplies.

(6) Location with Respect to Markets.—In order to achieve an established position in the trade a new cement plant should have (a) a local market area, within which it may sell practically on a non-competitive basis, and (b) easy access to a larger though competitive market area.

Methods of Manufacture of Portland Cement.

If the so-called "natural Portlands" are excluded, Portland cement may be regarded as an artificial product obtained by burning to semi-fusion an intimate mixture of pulverized materials containing lime, silica, and alumina in varying proportions within certain narrow limits, and by crushing finely the clinker resulting from this burning. If this restricted definition of Portland cement be accepted, four points may be regarded as being of cardinal importance: (1) The cement mixture must be of the proper chemical composition; (2) the materials must be carefully ground and intimately mixed before burning; (3) the mixture must be burned at the proper temperature; (4) after burning, the resulting clinker must be finely ground.

As the chemical composition of the mixture can be more advantageously discussed after the other three subjects have been disposed of, it will therefore be taken up last.

Preparation of the Mixture for the Kiln.

In the preparation of the mixture for the kiln the raw materials must be reduced to a very fine powder and intimately mixed. The raw materials are usually

* Abstract from Bulletin 243 of United States Geological Survey.

† For a more detailed discussion see Municipal Engineering, vol. xxiv., 1903, pp. 335-338, and American Geologist, vol. xxix., 1902, pp. 146-154.

crushed more or less finely, then mixed, and then ground to powder. Two general methods of treatment, the dry and the wet, are in use at different plants. Unless the limy constituent of the mixture is a marl, already full of water, the dry method is almost invariably followed. In this the materials are kept in as dry a condition as possible throughout the entire process of crushing and mixing, and if they originally contained a little moisture they are dried before being powdered and mixed. In the wet method, on the other hand, the materials are powdered and mixed while in a very fluid state, the mixture containing 60 per cent or more of water.

Percentage of Water in Raw Materials.

The percentage of water thus carried by the crude raw material will depend largely on the character of the material, partly on the method of handling and storing it, and partly on weather conditions.

In hard limestones, freshly quarried, the water will commonly range from one-half to 3 per cent, rarely reaching or exceeding the higher figure, except in the very wet quarries or during a rainy season. Such limestones, comparatively dry when quarried, are frequently sent to the grinding mills without artificial drying.

Soft, chalky limestones, which absorb water very rapidly, usually contain not more than 5 per cent of water in dry weather, while prolonged wet weather may necessitate the handling at the mill of material carrying as high as 15 to 20 per cent of water.

The clays present much more complicated conditions. In addition to the hygroscopic or mechanically held water, there is also always a certain percentage of chemically combined water. The amount of hygroscopic water will depend on the treatment and exposure of the clay, and may vary from 1 per cent in clays which have been stored and air dried to as high as 30 per cent in fresh clays. The chemically combined water will depend largely on the composition of the clay, and may vary from 5 to 12 per cent. The hygroscopic or mechanically held water of clays can be driven off at a temperature of 212 deg. F., while the chemically combined water is lost only at a low red heat. The total water, therefore, to be driven off from clays may range from 6 to 42 per cent, depending on the weather, the drainage of the clay pit, and the care taken to prevent unnecessary exposure of the excavated material to moisture. The average total amount of moisture will probably be about 15 per cent.

In dealing with shales the mechanically held water rarely amounts to more than about 10 per cent, and is commonly well below that limit. An additional 2 to 7 per cent of water will be carried by any shale in a state of chemical combination.

At a few plants marl is used with clay in a dry process. As noted elsewhere, the marls as excavated carry usually about 50 per cent of water. These present a more difficult problem than the other raw materials, because the vegetable matter usually present in marls is extremely retentive of water.

It will be seen, therefore, that cement materials may carry from 1 to 50 per cent of water when they reach the mill. In a dry process it is necessary to remove practically all of this water before commencing the grinding. One reason for this is that fine pulverizing cannot be economically or satisfactorily accomplished unless absolutely dry material is fed to the grinding machinery. Another reason, which is one of convenience rather than of necessity, is that the presence of water in the raw materials complicates the calculation of the cement mixture.

Methods and Costs of Drying.

With the exception of the marls and clays used in the wet method of manufacture, Portland cement materials are usually dried before the grinding is commenced. This is necessary because the raw materials, as they come from the quarry, pit, or mine, will almost invariably carry appreciable, though often very small, percentages of water which greatly reduces the efficiency of most modern types of grinding mills and tends to clog the discharge screens.

The type of drier commonly used in cement plants is a cylinder, approximately 5 feet in diameter and about 40 feet in length, set at a slight inclination to the horizontal and rotating on bearings. The wet raw material is fed in at the upper end of the cylinder, and it moves gradually toward the lower end under the influence of gravity as the cylinder revolves. In many driers angle irons are bolted to the interior in such a way as to lift and drop the raw material alternately, thus exposing it more completely to the action of the heated gases and materially assisting in the drying process. The dried raw material falls from the lower end of the cylinder into an elevator boot and is then carried to the grinding mills.

The drying cylinder is heated either by a separate furnace or by waste gases from the cement kilns. In either case the products of combustion are introduced into the cylinder at its lower end, are drawn through it, and escape up a stack set at the upper end of the drier.

The drier above described is the simplest and is most commonly used. For handling the small percentages of water contained in most cement materials it is very efficient, but for dealing with high percentages of water, such as are encountered when marl is to be used in a dry process, double-heating driers probably will be found more economical. This type is exemplified by the Ruggles-Coles drier, a detailed description of which is given in the Mineral Industry, volume 10, pages 84-95. In this drier a double cylinder is employed. The wet raw material is fed into the space between the inner and outer cylinders, while the heated gases pass first through the inner cylinder, and then, in a reverse direction, through the space between the inner and outer cylinders. This double-heating type of drier is employed in almost all of the slag cement plants in the United States and is also in use in several Portland cement plants.

When vertical kilns were in use drying floors and drying tunnels were extensively used, but at present they can be found in only a few plants, being everywhere else supplanted by the rotary driers.

The cost of drying will depend on the cost of fuel, the percentage of water in the wet material, and the type of drier. Even under the most unfavorable conditions it may be expected that 5 pounds of water will be evaporated per pound of coal used, while a good drier will usually evaporate 7 or 8 pounds of water per pound of coal.

Grinding and Mixing.

Dry Methods.

Part at least of the grinding is usually accomplished before the drying, but for convenience the subjects have been separated in the present paper. Usually the limestone is sent through a crusher at the quarry or mill, and occasionally the raw material is further reduced in a Williams mill, etc., before drying, but the principal part of the reduction always takes place after the material has been dried.

After the two raw materials have been separately dried they may be mixed immediately or each may be further reduced separately before mixing. Automatic mixers, of which many types are on the market, give a mixture in proportions determined from analysis of the materials.

The further reduction of the mixture is usually carried on in two stages, the material being ground to 30 mesh in a ball mill, comminuter, Griffin mill, etc. and finally reduced in a tube mill. At a few plants however, single-stage reduction is practised in Griffin or Huntington mills, while at the Edison plant at Stewartsville, N. J., the reduction is accomplished in a series of rolls.

The majority of plants use either the Griffin mill and tube mill or the ball and tube mills, and there is probably little difference in the cost of operating these two combinations. The ball mill has never been quite so successful as its companion, the tube mill, and has been replaced at several plants by the comminuter.

After the mixture is reduced, and when it is ready for burning, 90 to 95 per cent of it should pass through a 100-mesh sieve. In the plants of the Lehigh district the mixture is rarely crushed as fine as when limestone and clay are used. Newberry* has pointed out in explanation of this that an argillaceous limestone (cement rock) mixed with a comparatively small quantity of purer limestone, as in the Lehigh plants, requires less thorough mixing and less fine grinding than when a mixture of limestone and clay (or marl and clay) is used, for even the coarser particles of the argillaceous limestone will vary so little in chemical composition from the proper mixture as to affect the quality of the resulting cement but little should either mixing or grinding be incompletely accomplished.

A very good example of typical Lehigh Valley grinding of raw material is afforded by a specimen examined† by Prof. E. D. Campbell. This specimen of raw mix ready for burning was furnished by one of the best of the eastern Pennsylvania cement plants. A mechanical analysis of it showed the following results:

	Mesh of sieve.		
	50	100	200
Per cent passing.....	96.9	85.6	72.4
Per cent residue.....	3.1	14.4	27.6

The material, therefore, is so coarsely ground that only a trifle over 85 per cent passes a 100-mesh sieve.

Slag-Limestone Mixtures.

While the manufacture of Portland cement from slag and limestone is similar in general theory and practice to its manufacture from limestone and clay, there are certain interesting differences in the preparation of the mixture. In the following paragraphs the general methods of preparing mixtures of slag and limestone for use in Portland cement manufacture will first be discussed, after which certain processes peculiar to the use of this mixture will be described separately.

General Methods.—After it had been determined that puzzolanic cement, made by mixing slag with lime without subsequent burning, was not an entirely satisfactory structural material, attention was soon directed toward the problem of making a true Portland cement from such slag. The blast furnace slags commonly available, while carrying enough silica and alumina for a cement mixture, are too low in lime to be suitable for Portland cement. Additional lime must be added, usually in the form of limestone, and the slag and limestone must be well mixed and properly burned. The general methods for properly mixing the materials vary in details. It seems probable that the first method used in attempting to make a true Portland cement from slag was to dump the proper proportion of limestone broken into small lumps, into molten slag. The idea was that both mixing and calcination could thus be accomplished in one stage, but in practice it was found that the resulting cement was variable in composition and always low in grade. This method has accordingly fallen into disuse, and at present three different general processes of preparing the mixture are practised at different European and American plants.

1. The slag and limestone are granulated, dried, and ground separately. The two materials are then mixed in proper proportions, the mixture is finely pulverized in tube mills, and the product is fed in a powdered state to rotary kilns.

2. The slag is granulated, dried, and mixed with slightly less than the calculated proper amount of limestone, which has been previously dried and powdered. Sufficient powdered slaked lime (say 2 to 6 per cent) is added to bring the mixture up to correct composition. The intimate mixture and final reduction are then accomplished in ball-and-tube mills. About 8 per cent of water is then added, and the slurry is made into bricks, which are dried and burned in a dome or chamber kiln.

3. Slag is granulated and mixed, while still wet, with crushed limestone in proper proportions. This mixture is run through a rotary calciner, heated by waste kiln gases, in which the temperature is sufficient not only to dry the mixture, but also to partly powder it and to reduce most of the limestone to quicklime. The mixture is then pulverized and fed into rotary kilns.

Of the three general processes above described, the second is unsuited to American conditions. The first and third are adapted to the use of the rotary kiln. The third seems to be the most economical, and has given a remarkably low fuel consumption in practice, but so far has not been taken up in the United States.

Certain points of manufacture peculiar to the use of mixtures of slag and limestone will now be described.

Composition of the Slag.—The slags adapted to Portland cement manufacture are of common occurrence in iron-producing districts. The more basic blast-furnace slags are best suited for this use. The slags utilized will generally run from 30 to 40 per cent lime, but the higher the lime the better. The presence of over 3 per cent of magnesia renders a slag unfit for Portland cement material, and on this account slags from furnaces using dolomite (magnesian limestone) as a flux can not be used for cement manufacture. The presence of any notable percentage of sulphur is also a drawback, though part of the sulphur in the slag will be removed during the processes of manufacture.

Granulation of Slag.—If slag be allowed to cool slowly, it solidifies into a dense, tough material, without hydraulic properties, which is not readily reduced to the requisite fineness for a cement mixture. If it be cooled suddenly, however, as by bringing the stream of molten slag into contact with cold water, the slag is "granulated"—i. e., it breaks up into small porous particles—and is much more readily pulverized than a slowly cooled slag. Sudden cooling intensifies the chemical activity of its constituents so as to give it hydraulic properties while part of the sulphur contained in the original slag is removed. The sole disadvantage of the process of granulating slag is that the product contains 20 to 40 per cent of water, which must be driven off before the granulated slag is sent to the grinding machinery.

The granulation of the slag is effected by running the stream of molten slag from the furnace into a sheet-iron trough, in which flows a small stream of water whose rate of flow is so regulated as to give complete granulation of the slag without using an excessive amount of water. The trough may discharge the granulated slag into tanks or into box cars, which are usually perforated at intervals along the sides so as to allow part of the water to drain off.

Drying the Slag.—As above noted, the granulated slag may carry from 20 to 40 per cent of water. This is removed by treating the slag in rotary driers. In practice such driers give an evaporation of 6 to 10 pounds of water per pound of coal. The practice of slag drying is very fully described in volume 10 of the Mineral Industry, pages 84-95, where figures and descriptions of various driers are also given, with data on their evaporative efficiency. In one of the methods the slag is dried by waste heat from the kilns after it has been mixed with the limestone. Kiln gases could of course be used in the slag driers, but they have not been utilized except in plants following the method described.

Grinding the Slag.—Slag can be crushed with considerable ease to about 50 mesh, but notwithstanding its apparent brittleness it is difficult to grind it finer. Until the introduction of the tube mill it was almost impossible to reduce this material to the fineness necessary for a cement mixture, and the proper grinding of the slag is still an expensive part of the process as compared with the grinding of limestone, shales, or clay.

Composition of the Limestone.—As the slag carries all the silica and alumina necessary for the cement mixture, the limestone to be added to it should be simply a pure lime carbonate. The limestone used for flux at the furnace which supplies the slag will usually be found to be of suitable composition for use in making up the cement mixture.

Advantages of Using Slag-Limestone Mixtures.—The manufacture of a true Portland cement from a mixture of slag and limestone presents certain undoubted advantages over the use of any other raw materials, while it has also a few disadvantages.

Probably the greatest advantage is in the fact that the most important raw material—the slag—can usually be obtained more cheaply than an equal amount of rock could be quarried or mined. The slag is a waste product, which is hard to dispose of and may be obtained at small expense to the cement plant. Another advantage is due to the occurrence of the lime as oxide, and not as carbonate. The heat necessary to drive off the carbon dioxide from an equivalent mass of limestone is, therefore, saved when slag forms

* Twentieth Annual Report United States Geological Survey, pt. 6, p. 545.
† Journal American Chemical Society, vol. 25, p. 1106.

part of the cement mixture, and very low fuel consumption is obtained when slag limestone mixture is burned.

Of the disadvantages, the toughness of the slag and the necessity for drying it before grinding are probably the most important. A third disadvantage, not always apparent at first, is the difficulty of procuring a proper supply of suitable slag. Unless the cement plant is closely connected in ownership with the furnaces from which its slag supply is to be obtained this may become very serious. When there is a good market for iron the furnace manager will naturally give little thought to the question of supplying slag to an independent cement plant.

The advantages of the mixture, however, seem to outweigh its disadvantages, for the manufacture of Portland cement from slag is now a large and growing industry in both Europe and America. In this country two Portland cement plants have used slag and limestone as raw materials for some time; several others are in course of construction, and it seems probable that in the near future Alabama will join Illinois and Pennsylvania as an important producer of Portland cement from slag.

(To be continued.)

ELECTRICITY IN THE HOME.*

By HAROLD STANNARD.

ELECTRICITY, so extensively used in the commercial development of civilization, is rapidly becoming an important factor in the modern conveniences of the home. Employed in its earlier stages of use chiefly in the larger enterprises, such as power plants for railways or lighting systems of cities and towns, it is now being incorporated in the regime of the household for various purposes, and surprising progress has been made by manufacturers of electrical apparatus in the invention and production of utensils and devices designed for domestic service. In certain centers containing convenient sources of electrical supply, or where the people are more familiar with electricity than is usually the case with the average citizen, we find homes equipped throughout with electrical devices and apparatus which have almost entirely obviated many former necessities, for instance, coal, gas, and illuminating oil.

An excellent example of the development of electricity in the home is found in the residence of Mr. H. W. Hillman, at Schenectady, N. Y. The house, illustrated in four of the accompanying engravings, is the second of this type which Mr. Hillman has had constructed, and from the experience gained in the first building in the use of an electric cooking outfit no kitchen chimney was built, nor was it necessary to provide space for kitchen coal and wood, or for a cooking range. Therefore, it was only necessary to have a cellar under a portion of the house with, consequently, but half the excavation, while half the foundation walls were merely carried below the frost line. The house is heated during the winter months, it is true, by means of a furnace, as electric heating has not yet been developed to such an extent that the warming of an entire house from a central point is a practical possibility.

The electric cooking and baking outfit in the kitchen consists of an oak table, an oven, gridiron, meat broiler, cereal cooker, disk stove, frying pan and coffee percolator. The table is fitted with several indicating switches for controlling and regulating the devices. The servant easily learned to use the apparatus, and would very much dislike to go back to the old way of cooking by coal or gas. There is no coal to be brought up from the cellar, and there are no ashes to sift, nor is there a fire to watch and build up again should it go out. The monthly cost of operation has been carefully compared with gas and coal at $1.30 per thousand and $6.50 per ton respectively. The average monthly bill has been $6.69 for the past twenty-four months, an amount about 10 per cent higher than the average previous gas and coal bills. The initial cost of the electric cooking installation is about $55 or $60 complete, in other words about equal to that of a high grade coal range.

A water-plate in the furnace front supplies hot water for the entire house from October to May, while for the warmer months electric devices perform this service. For example, in the bathroom the electric immersion coil is placed in the bath tub whenever hot water is desired, and a sufficient supply is procurable within twenty to thirty minutes after the current has been switched on, at a cost of about two cents. Hot water for kitchen use is obtained with a similar apparatus. The bathroom is also provided with a small size water heater for shaving or for whatever purpose hot water may be required at any time of the day or night. It takes but a minute to heat water in this dish, and being portable it is a most convenient article for the house. Hot water for wash day is available during the winter from the furnace, and during the summer a nine-gallon electric wash-boiler is used. It requires about twenty minutes to heat a supply sufficient to commence washing. In connection with this heater is an electric washing machine, operated by a motor, and by its use the washing can be finished in less than half the usual time required. This is not only a labor saving device but it is easy to appreciate that the turning on and off of a switch is far more convenient and desirable than the building of a fire and attending it throughout the day. A motor of less than one-fourth horse-power is required to operate the washing machine, and the total cost per current is less than five cents a week. The washing machine can be purchased at any hardware store for $5 or $6, and the motor from any electric supply company at a price from $12 up. The ironing is done entirely by means

THE ELECTRICAL BATH-WATER HEATER.

ELECTRICAL HOT-WATER CUP.

THE ELECTRICAL CIGAR LIGHTER.

HEATING A NURSING BOTTLE BY ELECTRICITY.

AN ELECTRICAL CRIB WARMER.

IRONING BY ELECTRICITY IN THE NURSERY.

ELECTRICITY IN THE HOME.

* From American Homes and Gardens. Published by Munn & Co.

of electric irons, which have proven themselves one of the greatest conveniences which it is possible to have in the laundry, and which have obviated a great deal of discomfort and unnecessary arduous labor.

Electric radiators are of great convenience for auxiliary heat, particularly in the fall season, and at a small expense will furnish warmth and comfort within a few moments after being switched on. Radiators of this type are far superior to the gas log, as they do not vitiate the air of the room. The radiator may be of the luminous type, and then it furnishes a sentimental warmth and cheerfulness, like that of an open fireplace, on a winter evening. In this connection, an electric corn popper is an unending source of enjoyment to the children. It is not unlike the ordinary device of this character, but has a slightly thicker base for the heating element, and is provided with a roller which permits its use on the table, the floor or wherever desired. An electric chafing dish has been found a boon by the housewife, and has become a fixture in the dining-room. It is placed upon a small side table, which has a back board fitted with the necessary switches. These tables are now considered standard articles in a department store in Schenectady, and can be purchased complete at a cost slightly greater than that of an ordinary table. Electric cigar lighters have been found of great interest to smokers, and have been proven far superior to matches. By pressing a button on the device it will furnish heat to light a cigar in five or six seconds, and the cost is so insignificant that no mention need be made of it.

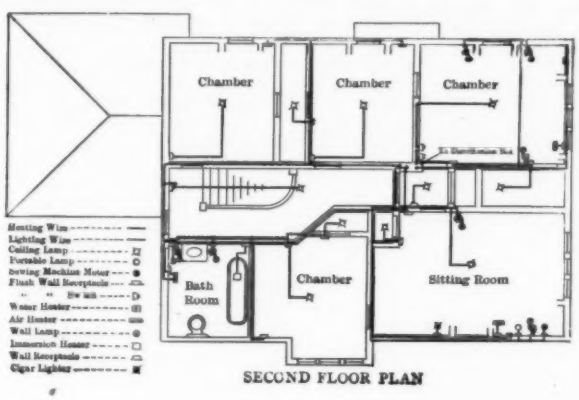
An electric massage motor has aroused a great deal of attention on the part of those who have seen it in Mr. Hillman's house. It comprises a small-sized motor, weighing four pounds, with a handle for holding it during the operation. Various applicators for the face, hands, arms, scalp, etc., complete the outfit, which can be attached to any lighting socket, and consumes, approximately, the same amount of electricity as an incandescent lamp. A five-minute application is most invigorating, and, according to professional opinion, it is equivalent to a walk of several miles.

Only those who have had experience with the electric heating pad can properly appreciate this useful article. It is a flexible woolen pad of any desired size, and is intended for use in place of the hot water bottle. In the case of a severe cold, the grippe, or a chill, this device can be attached to any lighting socket, and will furnish heat in three or four minutes. It has three degrees of regulation, and when on the lowest heat a patient can sleep in contact with the pad indefinitely without discomfort. The cost of operation is about that of an incandescent lamp when the highest degree of heat is used, but at the lowest rate the expense is only about one-third that of a lamp.

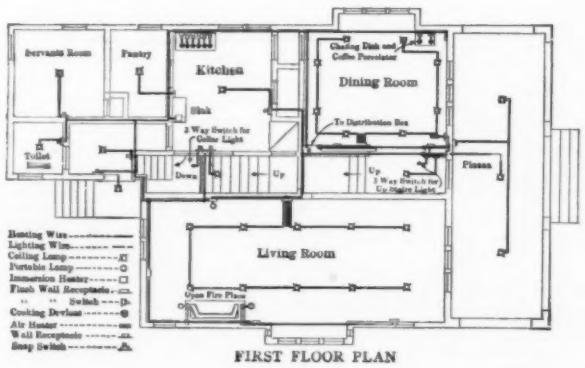
The expense of wiring the house for these various devices, in addition to the cost of the regular lighting circuits, was from $125 to $150. The saving, however, in the omission of a kitchen chimney and in the cellar construction more than offset the cost of the wiring and the initial cost of the devices. In smaller and less expensive houses it would be an easy matter to arrange the ordinary wiring so as to secure some of the conveniences mentioned. With a plan of this kind, the lighting circuit alone would be sufficient and receptacles for the convenient use of the devices could be installed at a small expense, thus obviating the necessity of unscrewing incandescent lamps when it was desired to use the heat devices. The accompanying diagrams show the electric wiring exactly as it is in Mr. Hillman's house. Those who wish to build $10,000 or $15,000 houses can well afford to have these buildings wired very completely. They may desire to use coal or gas ranges in the kitchens, but at the same time the architect could so plan the wiring that it would be possible to use electricity for cooking during the summer months. Mr. Hillman's first house was wired for electric lights only, yet the electric cooking outfit was successfully used for a year and a half. It is common practice for the main wires to be located in the cellar, and, as the kitchen is always on the first floor, it is inexpensive and easy to bring the wires up to the kitchen for the electric installation.

Even in so-called modern houses, the care of small children is attended by many contingencies and frequent emergencies, and when these occasions arise, the entire household is often upset to meet the demands of

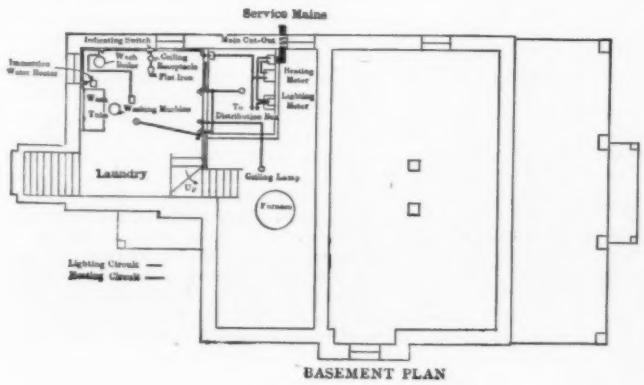
THE ELECTRICAL COOKING AND BAKING OUTFIT



SECOND FLOOR PLAN



FIRST FLOOR PLAN



BASEMENT PLAN

THE ELECTRICAL CHAFING DISH.

THE LUMINOUS ELECTRIC RADIATOR. BETTER THAN LOGS AND CHEAPER.

ELECTRICITY IN THE HOME.

the moment. Consequently numerous electrical devices for the nursery have proven of inestimable value, not only in emergency, however, but in general use as well. A number of the accompanying engravings illustrate certain of these devices and also the manner of their use. First we have the milk heater, a nickel receptacle of convenient size for the standard nursing bottle, provided with a coil heating element of the usual type. The convenience, cleanliness and practicability of this little apparatus cannot be overestimated, and the avoidance of a hurriedly lighted gas or alcohol flame, with the consequent danger of setting fire to something, is alone a great advantage. In this connection a small water heater is of value in the nursery, and a double bottom gruel cooker will save time and trouble.

These devices have undoubtedly proven their usefulness, but no less valuable in the case of the baby are the portable electric radiator, the coil bath heater, the heating pad and the small pressing iron. The latter is invaluable in pressing out the tiny garments, bonnets, ribbons and sashes which seem to be continually crumpled in the most unaccountable manner. The heating coil for the bathtub makes it possible to have the water at a constant and proper temperature, an operation formerly by no means easy to accomplish, while the radiator, if intelligently employed, may prevent many a cold. The heating pad needs little recommendation, not only as a substitute for the unwieldy hot-water bottle, but in general use as well, and if once used in the nursery, it will soon demonstrate its value.

[Continued from SUPPLEMENT No. 1586, page 25407.]

SIMPLE TESTS FOR THE DETECTION OF FOOD ADULTERANTS.*

DETERMINATION OF ARTIFICIAL COLORS.

Detection of Coal-Tar Dyes.

As has been stated, coloring matters used with foods are usually soluble in water. If the food under examination be a liquid, it may therefore be treated directly by the method given below. If it be a solid or a pasty substance, soluble in water either in the cold or after heating, it may be dissolved in sufficient water to form a thin liquid. If it contains some insoluble material, it may be treated with sufficient water to dissolve the soluble portion with the formation of a thin liquid and filtered, and then strained through a clean white cotton cloth to separate the insoluble portion. About a half teacupful of the liquid thus described is heated to boiling, after adding a few drops of hydrochloric acid and a small piece of white woolen cloth or a few strands of white woolen yarn. (Before using, the wool should be boiled with water containing a little soda, to remove any fat it may contain, and then washed with water.) The wool is again washed, first with hot and then with cold water, the water pressed out as completely as possible, and the color of the fabric noted. If no marked color is produced, the test may be discontinued and the product considered free from artificial colors. If the fabric is colored, it may have taken up coal-tar colors, some foreign vegetable colors, and if a fruit product is being examined, some of the natural coloring matter of the fruit. Rinse the fabric in hot water, and then boil for two or three minutes in about one-third of a teacupful of water and two or three teaspoonfuls of household ammonia. Remove and free from as much of the liquid as possible by squeezing or wringing. Usually the fabric will retain the greater part of the natural fruit color, while the coal-tar color dissolves in dilute ammonia. The liquid is then stirred with a splinter of wood and hydrochloric acid added, a drop or two at a time, until there is no longer any odor of ammonia. (The atmosphere of the vessel is sometimes charged with the ammonia for several minutes after it has all been driven out of the liquid; therefore one should blow into the dish to remove this air before deciding whether the ammonia odor has been removed or not.) When enough acid has been added the liquid has a sour taste, as may be determined by touching the splinter, used in stirring, to the tongue.

A fresh piece of white woolen cloth is boiled in this liquid and thoroughly washed. If this piece of cloth has a distinct color the food under examination is artificially colored. The color used may have been a coal-tar derivative, commonly called an anilin dye, or an artificial color chemically prepared from some vegetable color. If of the first class the dyed fabric is usually turned purple or blue by ammonia. In either case if the second fabric has a distinct color it is evident that the product under examination is artificially colored. Of course a dull, faint tint must be disregarded.

Detection of Copper.

The presence of copper, often used to deepen the green tint of imported canned peas, beans, spinach, etc., may be detected as follows:

Mash some of the sample in a dish with a stiff kitchen spoon. Place a teaspoonful of the pulp in a teacup with three teaspoonfuls of water and add 30 drops of strong hydrochloric acid with a medicine dropper. Set the cup on the stove in a saucepan containing boiling water. Drop a bright iron brad or nail (wire nails are the best and tin carpet tacks will not answer the purpose) into the cup and keep the water in the saucepan boiling for twenty minutes, stirring the contents of the cup frequently with a splinter of wood. Pour out the contents of the cup and examine the nail. If present in an appreciable amount the nail will be heavily plated with copper.

Caution.—Be careful not to allow the hydrochloric acid to come in contact with metals or with the flesh or clothing.

Detection of Turmeric.

In yellow spices, especially mustard and mace, turmeric is often employed. This is especially true of prepared mustard to which a sufficient amount of starch adulterant has been added to materially reduce the natural color. If turmeric be employed to restore the normal shade an indication of that fact may sometimes be obtained by mixing a half teaspoonful of the sample in a white china dish and mixing with it an equal amount of water, and a few drops (4 to 10) of household ammonia, when a marked brown color, which does not appear in the absence of turmeric, is formed. At the present time turmeric or a solution of curcuma (the coloring matter of turmeric) is sometimes added to adulterated mustard in sufficient amount to materially increase its color, but not to a sufficient extent to give the brown appearance with ammonia described above. In such cases a teaspoonful of the suspected sample may be thoroughly stirred with a couple of tablespoonfuls of alcohol, the mixture allowed to settle for fifteen minutes or more and the upper liquid poured off into a clean glass or bottle. To about 1 tablespoonful of the liquid thus prepared and placed in a small clear dish (a glass salt cellar serves excellently) add 4 or 5 drops of a concentrated solution of boric acid or borax and about 10 drops of hydrochloric acid, and mix the solution by stirring with a splinter of wood. A wedge-shaped strip of filter paper about 2 or 3 inches long, 1 inch wide at the upper end, and one-fourth inch at the lower end is then suspended by pinning, so that its narrow end is immersed in the solution, and is allowed to stand for a couple of hours. The best results are obtained if the paper is so suspended that air can circulate freely around it, i. e., not allowing it to touch anything except the pin and the liquid in the dish. If turmeric be present a cherry red color forms on the filter paper a short distance below the upper limit to which the liquid is absorbed by the paper, frequently from three-fourths of an inch to an inch above the surface of the liquid itself. A drop of household ammonia changes this red color to a dark green, almost black. If too much hydrochloric acid is used a dirty brownish color is produced.

Detection of Caramel.

A solution of caramel is used to color many substances, such as vinegar and some distilled liquors. To detect it two test tubes or small bottles of about equal size and shape should be employed and an equal amount (2 or 3 tablespoonfuls or more) of the suspected sample placed in each. To one of these bottles is added a teaspoonful of fullers' earth, the sample shaken vigorously for two or three minutes and then filtered through filter paper, the first portion of the filtered liquid being returned to the filter paper and the sample finally collected into the test tube or bottle in which it was originally placed, or a similar one. The filtered liquid is now compared with the untreated sample. If it is markedly lighter in color it may be taken for granted that the color of the liquid is due to caramel, which is largely removed by fullers' earth. In applying this test, however, it must be borne in mind that caramel occurs naturally in malt vinegar, being formed in the preparation of the malt. It is evident that the tests require practice and experience before they can be successfully performed. The housewife can use them, but must repeat them frequently in order to become proficient in their use.

EXAMINATION OF CERTAIN CLASSES OF FOODS.

Canned Vegetables.

As before stated, canned vegetables are relatively free from adulteration by means of foreign substances. The different grades of products may with care be readily detected by the general appearance of the sample. The purchaser is, of course, at the disadvantage of not being able to see the product until the can is opened. By a study of the different brands available in the vicinity, however, he can readily select those which are preferable. As stated in an earlier part of the bulletin, canned tomatoes sometimes contain an artificial coloring matter, which may be detected as described.

Canned sweet corn is sometimes sweetened with saccharin, which may be detected as described.

It is believed that as a rule canned vegetables are free from preservatives, although some instances of chemical preservation have recently been reported in North Dakota, and some imported tomatoes have been found by this Bureau to be artificially preserved. The presence of copper, often used for the artificial greening of imported canned peas, beans, spinach, etc., may be detected as described.

Coffee.

There are a number of simple tests for the presence of the adulterants of ground coffee. These tests are called simple because they can be performed without the facilities of the chemical laboratory, and by one who has not had the experience and training of a chemist. It must be understood, however, that they require careful observation and study, and that one must perform them repeatedly in order to obtain reliable results. Before applying them to the examination of an unknown sample, samples of known character should be secured and studied. Unground coffee may be ground in the home and mixed with various kinds of adulterants, which can also be secured separately. Thus the articles themselves in known mixtures may be studied, and when the same results are obtained with unknown samples they can be correctly interpreted. These tests are well known in the laboratory and may be used in the home of the careful housewife who has the time and perseverance to master them.

Physical Tests.—The difference between the genuine ground coffee and the adulterated article can often be detected by simple inspection with the naked eye. This is particularly true if the product be coarsely crushed rather than finely ground. In such condition pure coffee has a quite uniform appearance, whereas the mixtures of peas, beans, cereals, chicory, etc., often disclose their heterogeneous nature to the careful observer. This is particularly true if a magnifying glass be employed. The different articles composing the mixture may then be separated by the point of a penknife. The dark, gummy-looking chicory particles stand out in strong contrast to the other substances used, and their nature can be determined by one who is familiar with them by their astringent taste.

The appearance of the coffee particles is also quite distinct from that of many of the coffee substitutes employed. The coffee has a dull surface, whereas some of its substitutes, especially leguminous products, often present the appearance of having a polished surface.

After a careful inspection of the sample with the naked eye, or, better, with a magnifying glass, a portion of it may be placed in a small bottle half full of water and shaken. The bottle is then placed on the table for a moment. Pure coffee contains a large amount of oil, by reason of which the greater portion of the sample will float. All coffee substitutes and some particles of coffee sink to the bottom of the liquid. A fair idea of the purity of the sample can often be determined by the proportion of the sample which floats or sinks.

Chicory contains a substance which dissolves in water, imparting a brownish-red color. When the suspected sample, therefore, is dropped into a glass of water, the grains of chicory which it contains may be seen slowly sinking to the bottom, leaving a train of a dark-brown colored liquid behind them. This test appears to lead to more errors in the hands of inexperienced operators than any other test here given. Wrong conclusions may be avoided by working first with known samples of coffee and chicory as suggested above.

Many coffee substitutes are now sold as such and are advertised as more wholesome than coffee. Notwithstanding the claims that are made for them, a few of them contain a considerable percentage of coffee. This may be determined by shaking a teaspoonful in a bottle half full of water, as described above. The bottle must be thoroughly shaken so as to wet every particle of the sample. Very few particles of coffee substitutes will float.

Chemical Tests.—Coffee contains no starch, while all of the substances, except chicory, used for its adulteration and in the preparation of coffee substitutes contain a considerable amount of starch. The presence of such substitutes may, therefore, be detected by applying the test for starch. In making this test less than a quarter of a teaspoonful of ground coffee should be used, or a portion of the ordinary infusion prepared for the table may be employed after dilution. The amount of water that should be added can only be determined by experience.

Condimental Sauces.

Tomato catsup and other condimental sauces are frequently preserved and colored artificially. The preservatives employed are usually salicylic acid and benzoic acid or their sodium salts. These products may be detected by the methods given.

Coal-tar colors are frequently employed with this class of goods, especially with those of a reddish tint, like tomato catsup. They may be detected by the methods given.

Dairy Products.

Butter.—Methods are available which, with a little practice, may be employed to distinguish between fresh butter, renovated or process butter, and oleomargarin.

These methods are commonly used in food and dairy laboratories, and were originally suggested as household tests.* They give reliable results. At the same time considerable practice is necessary before we can interpret correctly the results obtained. Some process butters are on the market which can be distinguished from fresh butter only with extreme difficulty. During the last few years considerable progress has been made in the attempt to renovate butter in such a way that it will appear like fresh butter in all respects. A study must be made of these methods if we would obtain reliable results.

The "spoon" test has been suggested as a household test, and is commonly used by analytical chemists for distinguishing fresh butter from renovated butter and oleomargarin. A lump of butter two or three times the size of a pea is placed in a large spoon and heated over an alcohol or Bunsen burner. If more convenient, the spoon may be held above the chimney of an ordinary kerosene lamp, or it may even be held over an ordinary illuminating gas burner. If the sample in question be fresh butter it will boil quietly, with the evolution of many small bubbles throughout the mass which produce a large amount of foam. Oleomargarin and process butter, on the other hand, sputter and crackle, making a noise similar to that heard when a green stick is placed in a fire. Another point

* Abstract of a monograph by W. D. Bigelow and Burton J. Howard, published by the Department of Agriculture.

* Patrick. House hold tests for the detection of oleomargarin and renovated butter, Farmers' Bulletin No. 131.

of distinction is noted if a small portion of the sample be placed in a small bottle and set in a vessel of water sufficiently warm to melt the butter. The sample is kept melted from half an hour to an hour, when it is examined. If renovated butter or oleomargarin, the fat will be turbid, while if genuine fresh butter the fat will almost certainly be entirely clear.

To manipulate what is known as the "Waterhouse" or "milk" test, about 2 ounces of sweet milk are placed in a wide-mouthed bottle, which is set in a vessel of boiling water. When the milk is thoroughly heated, a teaspoonful of butter is added, and the mixture stirred with a splinter of wood until the fat is melted. The bottle is then placed in a dish of ice water and the stirring continued until the fat solidifies. Now, if the sample be butter, either fresh or renovated, it will be solidified in a granular condition and distributed through the milk in small particles. If, on the other hand, the sample consist of oleomargarin it solidifies practically in one piece and may be lifted by the stirrer from the milk.

By these two tests, the first of which distinguishes fresh butter from process or renovated butter and oleomargarin, and the second of which distinguishes oleomargarin from either fresh butter or renovated butter, the nature of the sample under examination may be determined.

Milk.—The oldest and simplest method of adulterating milk is by dilution with water. This destroys the natural yellowish-white color and produces a bluish tint, which is sometimes corrected by the addition of a small amount of coloring matter.

Another form of adulteration is the removal of the cream and the sale as whole milk of skimmed or partially skimmed milk. Again, the difficulty experienced in the preservation of milk in warm weather has led to the widespread use of chemical preservatives.

Detection of Water.—If a lactometer or hydrometer, which can be obtained of dealers in chemical apparatus, be available, the specific gravity of milk will afford some clew as to whether the sample has been adulterated by dilution with water. Whole milk has a specific gravity between 1.027 and 1.033. The specific gravity of skimmed milk is higher, and milk very rich in cream is sometimes lower than these figures. It is understood, of course, that by specific gravity is meant the weight of a substance with reference to the weight of an equal volume of water. The specific gravity of water, therefore, is exactly 1. It is obvious that if water be added to a milk with the specific gravity of 1.030, the specific gravity of the mixture will be somewhat below those figures.

An indication by means of a hydrometer or lactometer below the figure 1.027 therefore indicates either that the sample in question is a very rich milk or that it is a milk (perhaps normal, perhaps skimmed) that has been watered. The difference in appearance and nature of these two extremes is sufficiently obvious to make use of the lactometer or hydrometer of value as a preliminary test of the purity of milk.

Detection of Color.—As previously stated, when milk is diluted by means of water the natural yellowish-white color is changed to a bluish tint, which is sometimes corrected by the addition of coloring matter. Coal-tar colors are usually employed for this purpose. A reaction for these colors is often obtained in the method given below for the detection of formaldehyde. When strong hydrochloric acid is added to the milk in approximately equal proportions before the mixture is heated a pink tinge sometimes is evident if a coal-tar color has been added.

Detection of Formaldehyde.—Formaldehyde is the substance most commonly used for preserving milk and is rarely, if ever, added to any other food. Its use is inexcusable and especially objectionable in milk served to infants and invalids.

To detect formaldehyde in milk 3 or 4 tablespoonfuls of the sample are placed in a teacup with at least an equal amount of strong hydrochloric acid and a piece of ferric alum about as large as a pinhead, the liquids being mixed by a gentle rotary motion. The cup is then placed in a vessel of boiling water, no further heat being applied, and left for five minutes. At the end of this time, if formaldehyde be present, the mixture will be distinctly purple. If too much heat is applied, a muddy appearance is imparted to the contents of the cup.

Caution.—Great care must be exercised in working with hydrochloric acid, as it is strongly corrosive. It must not come in contact with the flesh or clothes of the operator nor with any metallic vessels and must be greatly diluted with water before it is poured into the sink.

Edible Oils.

Detection of Cotton-Seed Oil.—With the exception of cotton-seed oil, the adulterants ordinarily used with edible oils are of such a nature that the experience and training of a chemist and the facilities of a chemical laboratory are essential to their detection. There is, however, a simple test for the detection of cotton-seed oil, known as the Halphen test, which may be readily applied.

The reader is cautioned that great care must be taken in the manipulation of this test, as one of the reagents employed—carbon bisulphid—is very inflammable. The manipulator should use every possible safeguard and should see to it that only a small portion of his reagent is exposed at one time. The chemicals employed in the preparation of the reagent used for this test are not household articles. They may, however, be obtained in any pharmacy. The mixture should be prepared by a druggist rather than by an inexperienced person who desires to use it.

In order to perform the test 2 or 3 tablespoonfuls of this reagent are mixed in a bottle with an equal volume of the suspected sample of oil and heated in a vessel of boiling salt solution (prepared by dissolving 1 tablespoonful of salt in a pint of water) for ten or fifteen minutes. At the end of that time, if even a small percentage of cotton-seed oil be present, the mixture will be of a distinct reddish color, and if the sample consists largely or entirely of cotton-seed oil, the color will be deep red.

Eggs.

There is no better method for the testing of the freshness of an egg than the familiar one of "candling," which has long been practised by dealers. The room is darkened and the egg held between the eye and a light; the presence of dark spots indicates that the egg is not perfectly fresh, one that is fresh presenting a homogeneous, translucent appearance. Moreover, there is found in the larger end of a fresh egg, between the shell and the lining membrane, a small air cell which, of course, is distinctly transparent. In an egg which is not perfectly fresh this space is filled and hence presents the same appearance as the rest of the egg.

It is now a matter of considerable importance to be able to distinguish between fresh eggs and those that have been packed for a considerable time. Until recently that was not a difficult matter. All of the solutions that were formerly used extensively for that purpose gave the shell a smooth, glistening appearance which is not found in the fresh egg. This characteristic, however, is of less value now than formerly, owing to the fact that packed eggs are usually preserved in cold storage. There is now no means by which a fresh egg can be distinguished from a packed egg without breaking it. Usually in eggs that have been packed for a considerable time the white and yolk slightly intermingle along the point of contact, and it is a difficult matter to separate them. Packed eggs also have a tendency to adhere to the shell on one side and when opened frequently have a musty odor.

Flavoring Extracts.

Although quite a large number of flavoring extracts are on the market, vanilla and lemon extracts are used so much more commonly than other flavors that a knowledge of their purity is of the greatest importance. Only methods for the examination of those two products will, therefore, be considered.

Vanilla Extract.—Vanilla extract is made by extracting vanilla beans with alcohol. It consists of an alcoholic solution of vanillin (the characteristic flavoring matter of the vanilla bean) and several other products, chiefly resins, which, though present in but small amount and having only a slight flavor in themselves, yet affect very materially the flavor of the product. Vanilla extract is sometimes adulterated with the extract of the tonka bean. This extract to a certain extent resembles vanilla extract. The extract of the tonka bean, however, is far inferior to that of the vanilla bean. It has a relatively penetrating, almost pungent odor, standing in sharp contrast to the flavor of the vanilla extract. This odor is so different that one who has given the matter some attention may readily distinguish the two, and the quality of the vanilla extract may often be judged with a fair degree of accuracy by means of the odor alone.

Another form of adulteration and one that is now quite prevalent is the use of artificial vanillin in place of the extract of either vanilla or tonka beans. Artificial vanillin has, of course, the same composition and characteristics as the natural vanillin of the vanilla bean. Extracts made from it, however, are deficient in the resins and other products which are just as essential to the true vanilla as is vanillin itself. Since vanillin is thus obtained from another source so readily, methods for the determination of the purity of vanilla extract must depend upon the presence of other substances than vanillin.

Detection of Caramel.—The coloring matter of vanilla extract is due to substances naturally present in the vanilla bean and extracted therefrom by alcohol. Artificial extracts made by dissolving artificial vanillin in alcohol contain no color of themselves, and to supply it caramel is commonly employed. Caramel may be detected in artificial extracts by shaking and observing the color of the resulting foam after a moment's standing. The foam of pure extracts is colorless. If caramel is present a color persists at the points of contact between the bubbles until the last bubble has disappeared. The test with fullers' earth given for caramel in vinegar is also very satisfactory, but of course requires the loss of the sample used for the test.

Examination of the Resin.—If pure vanilla extract be evaporated to about one-third its volume the resins become insoluble and settle to the bottom of the dish. Artificial extracts remain clear under the same conditions. In examining vanilla extract the character of these resins is studied. For this purpose a dish containing about an ounce of the extract is placed on a teakettle or other vessel of boiling water until the liquid evaporates to about one-third or less of its volume. Owing to the evaporation of the alcohol the resins will then be insoluble. Water may be added to restore the liquid to approximately its original volume. The resin will then separate out as a brown flocculent precipitate. A few drops of hydrochloric acid may be added and the liquid stirred and the insoluble matter allowed to settle. It is then filtered and the resin on the filter paper washed with water. The resin is then dissolved in a little alcohol, and to one portion of this solution is added a small particle of ferric alum and to another portion a few drops of hydrochloric acid. If the resin be that of the vanilla bean, neither ferric alum nor hydrochloric acid will produce more than a slight change of color. With resins from most other sources, however, one or both of these substances yield a distinct color change.

For filtering, a piece of filter paper should be folded once through the middle, and again at right angles to the first fold. It may now be opened with one fold on one side and three on the other and fitted into a glass funnel. When the paper is folded in this manner the precipitated resins may be readily washed with water. When the washing is completed the resins may be dissolved by pouring alcohol through the filter. This work with the resins will require some practice before it can be successfully performed. It is of considerable value, however, in judging of the purity of vanilla extract.

Lemon Extract.—By lemon extract is understood a solution of lemon oil in strong alcohol. In order to contain as much lemon oil as is supposed to be found in high-grade extracts the alcohol should constitute about 80 per cent of the sample. The alcohol is therefore the most valuable constituent of lemon extract, and manufacturers who turn out a low-grade product usually do so because of their economy of alcohol rather than of lemon oil. Owing to the fact that lemon extract is practically a saturated solution of oil of lemon in strong alcohol the sample may be examined by simple dilution with water. A teaspoonful of the oil in question may be placed in the bottom of an ordinary glass tumbler and 2 or 3 teaspoonfuls of water added. If the sample in question be real lemon extract the lemon oil should be thrown out of solution by reason of its insolubility in the alcohol after its dilution with water. The result is at first a marked turbidity and later the separation of the oil of lemon on the top of the aqueous liquid. If the sample remains perfectly clear after the addition of water, or if a marked turbidity is not produced, it is a low-grade product and contains very little, if any, oil of lemon.

Fruit Products.

Adulteration of fruit products is practically confined to jellies and jams. Contrary to the general belief, gelatin is never used in making fruit jelly. In the manufacture of the very cheapest grade of jellies starch is sometimes employed. Jellies containing starch, however, are so crude in their appearance that the most superficial inspection is sufficient to demonstrate that they are not pure fruit jellies. From their appearance no one would think it worth while to examine them to determine their purity.

Natural fruit jellies become liquid on being warmed. A spoonful dissolves readily in warm water, although considerable time is required with those that are especially firm. The small fruits contain practically no starch, as apples do, and the presence of starch in a jelly indicates that some apple juice has probably been used in its preparation. (As stated above, jelly that has been thickened by starch paste will not be mistaken for fruit jelly.)

Detection of Starch.—Dissolve a teaspoonful of jelly in a half teacupful of hot water, heat to boiling and add, drop by drop, while stirring with a teaspoon, a solution of potassium permanganate until the solution is almost colorless. Then allow the solution to cool and test for starch with tincture of iodin, as directed later. Artificially colored jellies are sometimes not decolorized by potassium permanganate. Even without decolorizing, however, the blue color can usually be seen.

Detection of Glucose.—For the detection of glucose, a teaspoonful of the jelly may be dissolved in a glass tumbler or bottle in 2 or 3 tablespoonfuls of water. The vessel in which the jelly is dissolved may be placed in hot water if necessary to hasten the solution. In case a jam or marmalade is being examined, the mixture is filtered to separate the insoluble matter. The solution is allowed to cool, and an equal volume or a little more of strong alcohol is added. If the sample is a pure fruit product the addition of alcohol causes no precipitation, except that a very slight amount of proteid bodies is thrown down. If glucose has been employed in its manufacture, however, a dense white precipitate separates and after a time settles to the bottom of the liquid.

Detection of Foreign Seeds.—In addition to the forms of adulteration to which jellies are subject, jams are sometimes manufactured from the exhausted fruit pulp left after removing the juice for making jelly. When this is done residues from different fruits are sometimes mixed. Exhausted raspberry or blackberry pulp may be used in making "strawberry" jam and *vice versa*. Some instances are reported of various small seeds, such as timothy, clover, and alfalfa seed, having been used with jams made from seedless pulp.

With the aid of a small magnifying glass such forms of adulteration may be detected, the observer familiarizing himself with the seeds of the ordinary fruits.

Detection of Preservatives and Colors.—With jellies and jams salicylic and benzoic acids are sometimes employed. They may be detected by the methods given.

Artificial colors, usually coal-tar derivatives, are sometimes used and may be detected as described.

Meat Products.

As in many other classes of foods, certain questions important in the judgment of meats require practical experience and close observation rather than chemical training. This is especially true of meat products. The general appearance of the meat must largely guide the purchaser. If, however, the meat has been treated

with preservatives and coloring matter its appearance is so changed as to deceive him. The preservatives employed with meat products are boric acid, borax, and sulphites. The methods for the detection of sulphites are not suitable for household use.

Detection of Boric Acid and Borax.—To detect boric acid (if its sodium salt, borax, has been used the same reaction will be obtained) about a tablespoonful of the chopped meat is thoroughly macerated with a little hot water, pressed through a bag, and 2 or 3 tablespoonfuls of the liquid placed in a sauce dish with 15 or 20 drops of strong hydrochloric acid for each tablespoonful. The liquid is then filtered through filter paper, and a piece of turmeric paper dipped into it and dried near a lamp or stove. If boric acid or borax were used for preserving the sample the turmeric paper should be changed to a bright cherry-red color. If too much hydrochloric acid has been employed a dirty brownish-red color is obtained, which interferes with the color due to the presence of boric acid. When a drop of household ammonia is added to the colored turmeric paper, it is turned a dark green, almost black color, if boric acid is present. If the reddish color, however, was caused by the use of too much hydrochloric acid this green color does not form.

Caution.—The corrosive nature of hydrochloric acid must not be forgotten. It must not be allowed to touch the flesh, clothes, or any metal.

Detection of Colors.—The detection of coloring matter in sausage is often a difficult matter without the use of a compound microscope. It may sometimes be separated, however, by macerating the meat with a mixture of equal parts of glycerin and water to which a few drops of acetic or hydrochloric acid have been added. After macerating for some time the mixture is filtered and the coloring matter detected by means of dyeing wool in the liquid thus obtained.

Spices.

Although ground spices are very frequently adulterated, there are few methods that may be used by one who has not had chemical training, and who is not skilled in the use of a compound microscope, for the detection of the adulterants employed. The majority of the substances used for the adulteration of spices are of a starchy character. Unfortunately for our purposes, most of the common spices also contain a considerable amount of starch. Cloves, mustard, and cayenne, however, are practically free from starch, and the presence of starch in the ground article is proof of adulteration.

Detection of Starch in Cloves, Mustard, and Cayenne.—A half teaspoonful of the spice in question is stirred into half a cupful of boiling water, and the boiling continued for two or three minutes. The mixture is then cooled. If of a dark color, it is diluted with a sufficient amount of water to reduce the color to such an extent that the reaction formed by starch and iodin may be clearly apparent if starch be present. The amount of dilution can only be determined by practice, but usually the liquid must be diluted with an equal volume of water, or only one-fourth of a teaspoonful of the sample may be employed originally. A single drop of tincture of iodin is now added. If starch is present, a deep blue color, which in the presence of a large amount of starch appears black, is formed. If no blue color appears, the addition of the iodin tincture should be continued, drop by drop, until the liquid shows by its color the presence of iodin in solution.

Detection of Colors.—Spice substitutes are sometimes colored with coal-tar colors. These products may be detected by the methods given.

Vinegar.

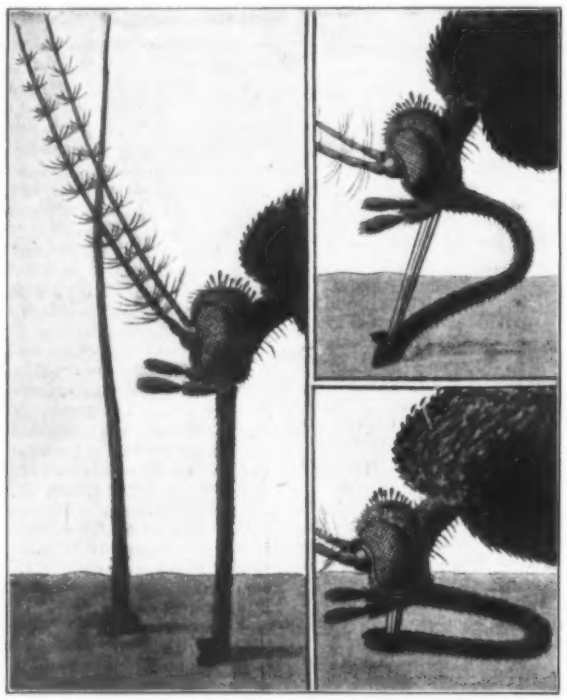
A person thoroughly familiar with vinegar can tell much regarding the source of the article from its appearance, color, odor, and taste.

If a glass be rinsed out with the sample of vinegar and allowed to stand for a number of hours or overnight, the odor of the residue remaining in the glass is quite different with different kinds of vinegar. Thus, wine vinegar has the odor characteristic of wine, and cider vinegar has a peculiar, fruity odor. A small amount of practice with this test enables one to distinguish with a high degree of accuracy between wine and cider vinegars and the ordinary substitutes.

If a sample of vinegar be placed in a shallow dish on a warm stove or boiling teakettle and heated to a temperature sufficient for evaporation and not sufficient to burn the residue, the odor of the warm residue is also characteristic of the different kinds of vinegar. Thus, the residue from cider vinegar has the odor of baked apples and the flavor is acid and somewhat astringent in taste, and that from wine vinegar is equally characteristic. The residue obtained by evaporating vinegar made from sugarhouse products and from spirit and wood vinegar colored by means of caramel has the peculiar, bitter taste characteristic of caramel.

If the residue be heated until it begins to burn, the odor of the burning product also varies with different kinds of vinegar. Thus, the residue from cider vinegar has the odor of scorched apples, while that of vinegars made from sugarhouse wastes and of distilled and wood vinegars colored with a large amount of caramel has the odor of burnt sugar. In noting these characteristics, however, it must be borne in mind that, in order to make them conform to these tests, distilled and wood vinegars often receive the addition of apple jelly.

As stated above, the cheaper forms of vinegar, especially distilled and wood vinegar, are commonly colored with caramel, which can be detected by the method given.



THE MOSQUITO'S BITING APPARATUS.

On the left is seen a much magnified picture of the mosquito's trunk, in which are inclosed the piercers, placed firmly against a human arm. The top picture on the right shows the piercer partly embedded in the flesh and in the lower one the mosquito has thrust its sharp piercer right down and is apparently enjoying its meal.

BITING APPARATUS OF THE MOSQUITO.

JUST how the mosquito bites a human being is a matter of some controvery, but the latest exposition is set forth by Dr. James Scott in London Countryside. He agrees that the male is not the offender. It is the female that stings man. She has a long, straight trunk, terminating in two lobes or sucking lips. Within this receptacle are five lancets while a slender one fits into a groove or slit, which divides the whole trunk lengthwise and permits the complete set of lancets to be withdrawn. When the mosquito is about to set to work, she fits the lips of the trunk against the skin and literally bores a hole into the flesh. In order to test her ability fully, Dr. Scott caught an insect and confined it as a prisoner inside the glass-topped lid from a circular box tied firmly to his arm.

As the six lancets, combined to form a single firm tool, were thrust deeper and deeper into the arm, the trunk became bent in a backward direction, vibrating like a gently waving leech in its act of suction. The slit was tightly closed meanwhile. Its two lips were firmly compressed against the hole from which the blood was oozing, and as the meal progressed it was possible to see plainly, through the thin membrane of the sides of the abdomen, the insect swelling to an abnormal extent and turning a vivid crimson color.

There remains the mystery of the varying intensity of mosquito stings. In some countries—notably in Egypt—the bite of the insect is transmitted to human consciousness in one quick agony. In the northern United States the pain, while intense, grows only gradually acute.—Current Literature.

SURVEYING ON THE FARM.*

A. S. KENYON, C.E.

MENSURATION.

BOTH the horizontal and vertical method of taking measurements, so far as applicable to the ordinary wants of the farmer, have now been gone into. Some of those given have their direct application, while others are of indirect use only. Their use involves what is known as Mensuration; that is, the finding of areas and volumes or quantities. The area of any figure or surface is the space contained between its length and breadth without any regard to its thickness. In the case of rectangular figures, that is with four right angles, the length and breadth are easily obtained. In triangles, the area is the base or breadth multiplied by half the perpendicular height, that is, the line drawn from the opposite angle at right angles to the base. If the triangle has one angle a right angle, the area then is half the result of the multiplication of the two sides forming the right angle. The area of a parallelogram, a four-sided figure with its opposite sides parallel, is the base multiplied by the perpendicular height, or, to put it another way, one side multiplied by its right angled distance from the other side—see Fig. 1. The area of a trapezoid, a four-sided figure with two sides only parallel, is the two parallel sides added together and multiplied by one-half their distance apart measured at right angles.

MEASUREMENT OF AREAS.

The definitions and rules just given may seem rather confusing; but their practical application is simple. Any paddock, no matter how irregular, so long as its sides are straight, may be divided into trapezoids and triangles, the triangles being generally right-angled. In such an instance as given in Fig. 2, a line is chained from the angle at A to the opposite angle at D. Along the line perpendiculars are laid out and measured, to all the remaining angles, B, C, E, F. Then it will be seen that the area of the whole paddock is cut up into four triangles and two trapezoids. Their areas are—Triangle A B H equals the length from A to H multiplied by one-half the distance from H to B; the trapezoid H B C K is given by the length B H added to C K and multiplied by one-half of the distance from H to K, which is the perpendicular distance between the two parallel sides, B H, C K; the triangle K C D similarly equals K D multiplied by one-half K C. In like manner the areas of the two triangles and the trapezoid below the line A D may be found. The addition of all these areas will give the total area sought for.

Taking the measurements given in the figure, the areas are—

Triangle A B H, 400 multiplied by one-half of 370 equals	74,000
Trapezoid H B C K, 370 added to 470, multiplied by one-half of 420 equals	176,400
Triangle K C D, 150 multiplied by one-half of 470 equals	35,250
Triangle A G F, 100 multiplied by one-half of 250 equals	12,500
Trapezoid G F E J, 250 added to 330, multiplied by one-half 500 equals	145,000
Triangle J D E, 370 multiplied by one-half of 330 equals	61,050
Total	504,200

The measurements are in links and the area sought is consequently 5.04 acres, or 5 acres 0 roods 7 perches.

In four-sided paddocks, which are not parallelograms or trapezoids, perpendiculars may be set up from one side only, two triangles and a trapezoid resulting, though in general, the measurement across the diagonal giving two triangles only is preferable—Fig. 2. The areas of the two triangles may be found by setting up perpendiculars as just explained. Should, however, the perpendiculars be difficult to measure, the following rule may be employed to find the areas of the triangles. In this case, measurements of the sides are required as well as the length of the diagonal. To find the area of a triangle when the lengths of all three sides are known, add the whole three lengths together and divide the sum by two. Call this result the half-sum; subtract from the half-sum each side in turn. Then multiply together the half-sum and each of the three remainders. The square root of the result will be the area of the triangle. Expressed in symbols, calling the sides a, b, and c, and the half-sum, that is, $a + b + c$ divided by two, S, the rule is—

$$\text{Area of triangle} = \sqrt{S \times (S-a) \times (S-b) \times (S-c)}.$$

This method involves measurement of the sides of the figure, and consequently is on the whole rather more cumbersome than the perpendicular method. All the examples given suppose it possible to get free access to any part of the inside of the paddock, but if only the outside is readily accessible, the method is still simple. Chain along one side; continue chaining, if necessary, until opposite perpendicularly the outermost angle. Extend the perpendicular through that angle, measuring offsets to the intervening angles, and chain along until another perpendicular can be set up to the next outermost angle. Chaining

* Journal of Agriculture (Victoria).

along thus, setting up perpendiculars to each angle, the result will be a rectangle, of which the area is, of course, readily found, inclosing the area sought for. The triangles and trapezoids outside the paddock, but inside the rectangle, are now to be calculated and their total subtracted from the area of the rectangle. The result will be the area of the paddock. Fig. 3 will show plainly the method.

Using the measurements given in the figure, the area of the rectangle is 490 multiplied by 280, equals 543,200. From this has to be subtracted the outside triangles and trapezoids—

Trapezoid B H J C, 440 added to 400, multiplied by one-half of 90, equals	37,800
Trapezoid C J K D, 400 added to 130, multiplied by one-half of 170 equals	45,050
Triangle D K E, 200 multiplied by one-half of 130, equals	13,000
Triangle E L F, 100 multiplied by one-half of 870, equals	43,500
Trapezoid F M N G, 100 added to 170, multiplied by one-half of 360, equals	48,600
Triangle A N G, 200 multiplied by one-half of 170, equals	17,000
Total	204,950

Deducting this from 543,200, the area of the rectangle, we have 338,250, or 3.38 acres, as the area of the irregular paddock.

All the examples given are of paddocks with straight sides. Very often a boundary is not straight, being a creek or a railway curve or some other irregular line. Cut off the curved or irregular boundary by a straight line ranged across the paddock—see Fig. 4. The irregular portion may be cut off by more than one line if the circumstances make that course preferable. The result, however, of cutting off the irregular portion is to give a paddock with straight sides, the area of which can be obtained by the methods already given, and a portion, generally a narrow strip with one or more straight sides and an irregular boundary. The area of this may be found by measuring offsets, or the distances of the irregular line from the straight one, and applying to them a rule known as Simpson's. Divide the straight line after measurement into an even number of equal distances. At each of the points thus obtained, including the two ends of the line, measure the distance to the irregular boundary; the distances should be measured at right angles to the straight line, found generally with sufficient accuracy by sighting. These measurements are called offsets. As the number of spaces was even, and measurements were taken at both ends as well as in between, the offsets must be an odd number. Now add the first and last offsets—those at the ends of the line—add all the odd-numbered ones and multiply the sum by two, add all the even-numbered ones and multiply them by four. Add all the results together, multiply them by the equal distance apart of the offsets and divide by three. In Fig. 4 the first and last offsets are each nothing, as the irregular line passes through the ends of the straight line; the third, fifth, seventh, ninth, and eleventh, the odd-numbered ones, add up to 1,540; this multiplied by two, gives 3,080; the even numbers, second, fourth, etc., yield 1,600 and multiplied by four 6,400. The sum of all these, 0, 3,080 and 6,400, is 9,480; multiplied by the distance apart, namely, 100, we get 948,000, and this, divided by three, gives 316,000 square links or 3.16 acres the area of the piece in question. The distance apart of the offsets will depend upon the conditions and the amount of accuracy required. If the boundary be fairly regular or a curve they may be as much as several chains apart. All areas found by the methods given will be in square feet if the original measurements are in feet, or square links, if originally in links. Square feet may be turned into acres by dividing by 43,560, the number of square feet in an acre. Square links may be reduced by cutting off the last five figures, 10 square chains or 100,000 square links forming one acre.

MENSURATION MEMORANDA.

Cases will occur where measurements of areas of circles or similar curves are required. It will be convenient to group here for reference the properties of some of the more important figures and bodies.

The circumference of a circle, i. e., the measurement around it, is the diameter multiplied by 3 and 1-7th, or the radius multiplied by 6 and 2-7ths.

The area of a circle is:

- the square of the diameter multiplied by .785, or, more roughly, 4-5.
- the diameter multiplied by the circumference and divided by 4.
- one-half the diameter multiplied by one-half the circumference.
- the circumference squared and divided by 12.6, or multiplied by .08 or 7-88ths.
- the radius squared and multiplied by 3 1-7th.

The area of an ellipse is the bigger diameter multiplied by the smaller diameter and multiplied again by .785 or 4-5ths.

The area of the surface of a sphere is the diameter squared and multiplied by 3 and 1-7th; that is, it is four times the area of a circle of the same diameter.

The volume of a sphere is the diameter cubed; that is, multiplied by itself twice running, and multiplied by .5236.

The area of the surface of a cylinder is the circumference, found as above, multiplied by the height; if necessary, add the areas of the circles forming the ends.

The volume of a cylinder is the area of the circle forming the base multiplied by the height.

The area of the surface of a cone is the circumference multiplied by the slant height divided by two, with the area of the base added, if required.

The volume of a cone and of a pyramid—that is, a body formed by three or more triangles meeting at a point and by a straight-sided figure forming the base—is the area of the base multiplied by the height and divided by three.

The volume of a frustum of a cone or pyramid is the areas of the two ends added to the square root of their product, multiplied by the height and divided by three.

The volume of a wedge—that is, a body formed by five flat surfaces; two, the sides, being trapezoids, two, the ends, triangles, and one four-sided figure for the base—is the length of the edge added to twice the length of the base and then multiplied by the width of the base and by the height, and the result divided by six.

THE PRISMOIDAL FORMULA.

Excepting the sphere, all the solids referred to are cases of the *prismoid*. The prismoid may be described as a solid body having for its ends two parallel plane or flat faces and all other boundaries straight, that is a straight edge placed on a boundary should coincide with it from end to end. The great majority of solids, the contents of which may be required, are prismoids; exceptions are barrels, spheres, etc., all having bulging sides. The volume of a prismoid is found by adding the two end areas to four times the middle area, multiplying by the distance apart of the ends and dividing the result by six. The middle area referred to is the area of the body at a point equally distant from the two ends, and is not the mean of the two end areas. As a general rule, one practically applicable to all cases likely to occur in farm practice—four times the middle area is the same as the multiplication of the two end lengths by the two end breadths. Thus the rule becomes the multiplication of the end lengths by the end breadths, and of the addition of the two end lengths by the addition of the two end breadths, all added together; multiplied by the distance apart of the ends, and divided by six.

STACKS.

The practical application of these rules and formulæ will now be given. In the first instance, hay or straw stacks will be dealt with. One of the most common methods for calculating rectangular stacks—the one used by most insurance companies—is: Ascertain the length and breadth about half-way between the ground and the eaves, and find the height from the ground to the eaves and from the eaves to the ridge. The contents are found by multiplying the length by the breadth and by the mean height. The mean height is generally taken as the height from the ground to the eaves with one-third of the height from the eaves to the ridge added. Sometimes one-half the eaves to ridge height is allowed. The one-third method is never right, nor does it or the one-half method approach the truth, unless the walls are vertical and the ends of the top vertical and not sloping—an unusual form of stack. The error is always in favor of the buyer; never of the seller. Using the prismoidal formula, the measurements required for a rectangular stack are the length and breadth at the ground and at the eaves; the height to the eaves, and from there to the ridge; and the length of the ridge. There are but few more measurements, and the results obtained are exactly correct. Take the following instance: A stack of 50 feet by 10 feet at the ground, and 60 feet by 20 feet at the eaves, and 50 in length along the ridge. The length and breadth one-half way up are consequently 55 feet and 15 feet respectively. The height to the eaves is 10 feet and from there to the ridge 6 feet The contents by the one-third method will be:

55 multiplied by 15 equals 825. 825 multiplied by 10 feet, the eaves height with one-third of 6 feet, from eaves to ridge, added, that is by 12 feet, equals 9,900 cubic feet.

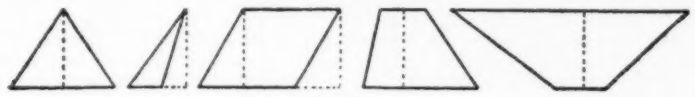


FIG. 1.

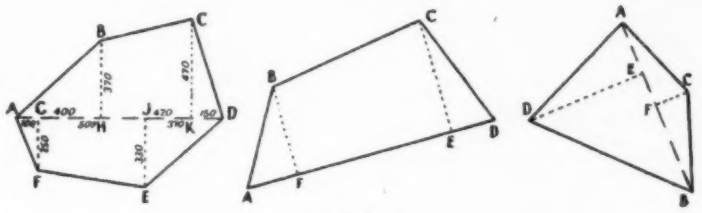


FIG. 2.

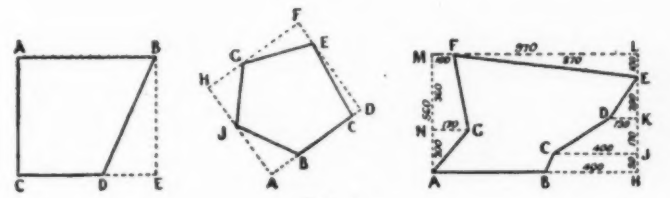


FIG. 3.

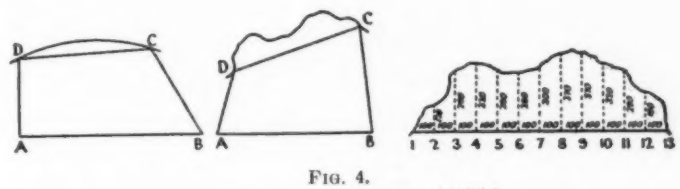


FIG. 4.

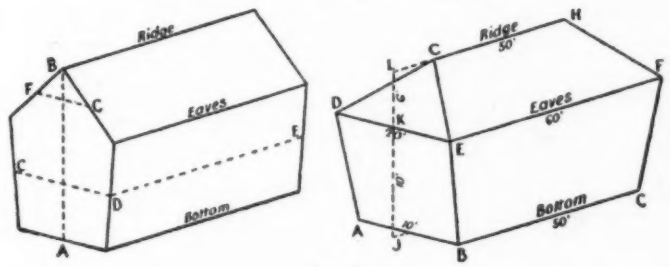


FIG. 5.

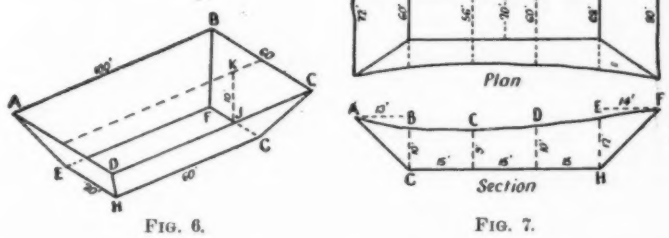


FIG. 6.

FIG. 7.

By the one-half method, it is:

825, as before, multiplied by 10 and 3, one-half the eaves to ridge height, that is by 13, equals 10,725 cubic feet.

By the prismoidal method, the stack is divided into two portions or prismoids, one part above the eaves, the top, and the other, the bottom, below the eaves. Following the rule given, the contents are:

The top—breadth at ridge, 0 feet by length at ridge, 50 feet equals 0; breadth at eaves, 20 feet by length at eaves 60 feet, equals 1,200; sum of breadths at ridge and eaves 20 by sum of lengths at ridge and eaves, 110 equals 2,200.

The addition of these is 3,400; multiplied by the height, 6 feet, we get 20,400, and this divided by six gives 3,400 cubic feet, which are the contents of the top.

The bottom—breadth at eaves 20 feet by length at eaves 60 feet equals 1,200; breadth at ground 10 feet by length at ground 50 feet, equals 500; sum of breadths at eaves and ground 30 by sum of length at eaves and ground, 110 feet equals 3,300. The addition of these is 5,000; multiplied by the height 10 50 feet, 50,000; and divided by six, 8,333 cubic feet, the bottom contents.

Adding the top and bottom together, we have 11,733 cubic feet as the correct volume of the stack, as compared with 10,725 and 9,900 given by the approximate methods, nearly 9 and 16 per cent below the truth (Fig. 5). If the stack have rounded ends, it may readily be converted into an equivalent rectangular stack by deducting one-fifth of the length of the rounded ends, and leaving the width unaltered. For instance, a stack is 30 feet long, with rounded ends starting to curve 5 feet from the ends. The length for the purposes of measurement would be the 20 feet of straight length with 4 feet (instead of 5 to allow for the curve) added at each end, or 28 feet in all. Width and ridge length would remain as measured. Circular stacks are generally small. An approximate rule is to multiply half the circumference, measured half-way between ground and eaves by half the diameter at the same point and multiply by one-third the height from the eaves to the peak added to the height of the eaves from the ground. If more convenient, any other of the methods given for finding the area of a circle may be used in place of the half circumference and half diameter one just given. The more exact way is, as before, to calculate in two parts top and bottom. The contents of the top are the circumference at the eaves multiplied by itself, multiplied again by 7-88ths, and the result by one-third of the height from the eaves to the peak. The bottom is: the circumference at the eaves multiplied by itself, the circumference at the ground multiplied by itself, and the sum of the two circumferences, multiplied by itself; the whole three results added and multiplied by 7-88ths and by one-sixth of the height from the ground to the eaves. Add the top and bottom results together to get the total contents of the stack.

WEIGHT OF HAY, ETC.

The results obtained by these methods are in cubic feet. The number of cubic feet to the ton is very variable, depending chiefly upon the size of stack, the time stacked, and the class. The best method, though a little troublesome, is to cut out a truss about halfway up the stack—the pressure there being about the average. Measure the contents of the cut in the stack, not the truss itself, and weigh the truss. This will give the weight of a cubic foot, and the total weight of the stack can then be set down with fair accuracy. The following table will be useful:

If 1 cubic foot of hay weighs 8 lbs., 1 ton measures 280 cubic feet.

If 1 cubic foot of hay weighs 7 lbs., 1 ton measures 320 cubic feet.

If 1 cubic foot of hay weighs 6 lbs., 1 ton measures 373 cubic feet.

If 1 cubic foot of hay weighs 5 lbs., 1 ton measures 448 cubic feet.

If 1 cubic foot of hay weighs 4 lbs., 1 ton measures 560 cubic feet.

If 1 cubic foot of hay weighs 3 lbs., 1 ton measures 747 cubic feet.

If the truss method is not used, the following table will enable a fair guess to be made:

Number of Cubic Feet to 1 Ton of Hay.

	Oaten hay.		Wheaten hay.	
	Sh'v'd.	Loose.	Sh'v'd.	Loose.
New, just stacked	350	400	400	500
New, fortnight stacked	325	370	375	450
New, one month in stack	300	350	350	400
Old, last season's stack, from	300	325	320	400
Old, last season's stack, to	250	320	270	370

In some cases, coarse stalky hay will weigh even less than the worst figures given in the table. Allowance must be made for the thatch, if any, on the top, and for the inferior quality of stuff generally found near the ridge.

TANKS, ETC.

Tanks, embankments, or excavation may be readily calculated by the prismoidal formula or the modification of it given. For tanks, where the water contents are wanted, or where the ground is fairly level at the top surface, multiply the length and breadth at the top—ground or water level as required—the length and breadth at the bottom, and the lengths at the top and bottom added together by the sum of the breadths. Add the three results and multiply by the depth and divide by six. In Fig. 6, with the dimensions given, the quantities are:

Top breadth, 60 feet by top length 100 feet, equals	6,000
Bottom breadth 20 feet by bottom length 60 feet, equals	1,200
Top and bottom breadths, 80 feet by top and bottom lengths 160 feet, equals	12,800
Total	20,000

Multiply by the depth, 10 feet, result 200,000, and divide by 6, giving 33,333, the number of cubic feet in the tank. To obtain the number of cubic yards, divide the cubic feet by 27, or to obtain gallons, multiply the cubic feet by 6¼. The same method will apply to a heap of broken metal or a bank, if the surface of ground at the bottom is level. If the surface be irregular, whether for a tank or an embankment, several vertical and parallel cross-sections, cutting the object into small portions, are required. In Fig. 7 is shown a tank with surface very irregular; cross sections are taken as shown, and the excavation calculated in sections. The width at the commencement is 72 feet, and the depth, of course, nothing; the width at the first cross section is 60 feet at the surface and 20 feet at the bottom, an average width of 40 feet and the depth 10 feet. The contents of this first portion are:

Width 72 feet by depth 0, equals	0
Average width 40 feet by depth 10 feet equals	400
Sum of widths 112 feet by sum of depths 10 feet, equals	1,120
Total	1,520

Multiplied by the distance apart of the cross-sections 13 feet, and divided by 6, we have 3,293.

The next portion, the second is:

Average width 40 feet, by depth 10 feet, equals	400
Average width 38 feet, by depth 9 feet, equals	342
Sum of widths 78 feet, by sum of depths 19 feet, equals	1,482
Total	2,224

Multiplied by 15 feet, and divided by 6, equals 5,560.

The third portion is:

Average width 38 feet, by depth 9 feet, equals	342
Average width 40 feet, by depth 10 feet, equals	400
Sum of widths 78 feet, by sum of depths 19 feet, equals	1,482
Total	2,224

Multiplied by 15 feet, and divided by 6, equals 5,560.

The fourth portion is:

Average width 40 feet, by depth 10 feet, equals	400
Average width 44 feet, by depth 12 feet, equals	528
Sum of widths 84 feet, by sum of depths 22 feet, equals	1,848
Total	2,776

Multiplied by 15 feet and divided by 6, equals 6,940.

The fifth and last portion is:

Average width 44 feet, by depth 12 feet, equals	528
Width 80 feet, by depth 0, equals	0
Sum of widths 124 feet, by sum of depths 12 feet, equals	1,488
Total	2,016

Multiplied by 14 and divided by 6 equals 4,704.

The total for the whole excavation is therefore 26,057 cubic feet, or 965 cubic yards.

Similarly any long excavation such as a channel, or banking such as a road formation, may be taken out by the modified prismoidal formula, with the certainty that the results are correct and not merely approximate with an unknown amount of error.

TIMBER, LOGS, ETC.

For round logs, multiply length by the quarter-girth, multiplied by itself. This will give approximately the sawn timber result. To get the actual contents of the log, multiply length by the average girth multiplied by itself, and divided by 12.6, or multiplied by 7-88ths. A ton of firewood varies from 40 cubic feet, the selling rate, to 50 or 52 feet, buying rate. On the Murray River, the ton is 4 feet by 4 feet measured on the face of the stack irrespective of the length of the wood. Thus 5-feet wood gives 80 cubic feet, and 2-feet wood 32 cubic feet to the ton. A cord of firewood is a stack 8 feet by 4 feet by 4 feet, or 128 cubic feet.

MISCELLANEOUS QUANTITIES.

A rod of brickwork is 30¼ square yards, that is 272¼ square feet, one brick and a half thick. Find the area of the surface in square feet; divide by 272¼; multiply by the number of half-bricks in the thickness of the wall, and divide by 3. Brickwork is now generally taken out in cubic yards. Metals frequently come into quantity calculations. One square foot 1 inch thick,

of wrought iron weighs	40.0 lbs.
of cast iron weighs	37.5 lbs.
of steel weighs	40.8 lbs.
of zinc weighs	37.5 lbs.
of brass weighs	43.7 lbs.
of copper weighs	46.2 lbs.
of lead weighs	59.3 lbs.
of gold weighs	100.0 lbs.

An equivalent volume of water weighs only 5.2 lbs. Five cubic feet of cast iron weigh one ton. Rough and ready approximations for carting, or for widths of tires, are as follows:

Hardwood, sawn, 800 feet super, 6 in. x 1 in.			—1 ton
Sleepers	30	cubic feet	—1 ton
Props	30	cubic feet	—1 ton
Rails	40	cubic feet	—1 ton
Posts	30	cubic feet	—1 ton
Piles, in the round	35	cubic feet	—1 ton
Piles, squared	30	cubic feet	—1 ton
Stone, rough	14	cubic feet	—1 ton
Stone, dressed	13	cubic feet	—1 ton
Spalls	25½	cubic feet	—1 ton
Road metal and screenings	23	cubic feet	—1 ton
Pitchers	19	cubic feet	—1 ton
Gravel	22	cubic feet	—1 ton
Sand	25	cubic feet	—1 ton
Lime	10	bushel bags	—1 ton
Wool, pressed, greasy	6	bales	—1 ton
Wool, pressed, washed	8	bales	—1 ton
Hay, pressed	135	cubic feet	—1 ton
Potatoes, 12 4-bushel or	15	gunny bags	—1 ton
Bran and pollard	108	bushels	—1 ton
Barley	11	bags	—1 ton
Chaff	25	bags	—1 ton
Flour	11	4-bush. bags	—1 ton
Maize, whole	10	bags	—1 ton
Maize crushed	11	bags	—1 ton
Oats	13	bags	—1 ton
Wheat	9	bags	—1 ton
Peas	9	bags	—1 ton
Bricks	1000		—3 tons

Steel Fencing Wire:

No. 6 gauge, 361 yards to 1-cwt. coil, 4 cwt. 3 qrs. 14 lbs. to 1 mile.

No. 7 gauge, 428 yards to 1-cwt. coil, 4 cwt. 0 qrs. 13 lbs. to 1 mile.

No. 8 gauge, 509 yards to 1-cwt. coil, 3 cwt. 1 qr. 23 lbs. to 1 mile.

No. 9 gauge, 609 yards to 1-cwt. coil, 2 cwt. 3 qrs. 15 lbs. to 1 mile.

No. 10 gauge, 747 yards to 1-cwt. coil, 2 cwt. 1 qr. 12 lbs. to 1 mile.

Barbed wire:

No. 12 gauge, 490 yards to 1-cwt. coil, barbs 3½ in. apart.

No. 14 gauge, 770 yards to 1-cwt. coil, barbs 3½ in. apart.

WATERPROOFING.*

By J. L. MOTHERSHEAD, JR.

THE waterproofing of concrete blocks is a subject of the greatest importance to all who are in any way interested in the manufacture of this building material. I think it may safely be said that the life of the whole industry depends on it.

The common clay brick are not waterproof, but the public has become so accustomed to their use and to their disadvantages that in getting something to take their place we must have an article which has all of their advantages and none of their disadvantages; consequently we must build dry houses with concrete blocks and without furring, or the public will soon stop using the blocks.

The first culprit is the manufacturer of machines, who sells one to a lawyer, doctor, or some other such inexperienced worker in cement, and then leaves him to work out his own salvation.

Then we come to the block manufacturer who believes that any Tom, Dick, or Harry can make good blocks, and that all he needs is some dirty sand and a little cement. He sells a few blocks because they look all right, and that is the only test that the customer knows how to apply. As the blocks are poor, they give rise to constant trouble, and during the rainy season the water goes through the walls in which they are placed as it would through a sieve.

But the man who injures the industry the most is the one who buys a machine and goes to making his own blocks on his building site, using poor material, without proper mixing, and then as time is an item he puts the blocks into the wall without any curing. My attention was attracted to a cement house in Indianapolis, which was built in this manner. The blocks were so poorly made that with a small stick you could dig holes in them. I reported it to the building inspector, but he seemed unable to do anything, and so the house stands to-day as an example of concrete block construction.

First, make good blocks. We have before us the question of making them correctly. It is impossible to attempt waterproof houses unless the blocks are well made and well cured. Too much cannot be said on this point, and our only hope is that the quality of the average block will improve as the industry grows older. That is the first thing to strive for—honest material, made into blocks in an honest manner and well cured. This alone will not produce waterproof blocks, but we must have it as a foundation or any special design or use of chemicals will fail.

Second, comes the use of a richer material as a facing for the blocks. All reasoning tends to condemn this method, as there will be two rates of contraction and expansion in the same block, and the natural result will be a splitting apart of the two mixtures. Some manufacturers claim that by making the blocks face down the danger of the occurrence is removed. Perhaps it is, and perhaps it is not; experience alone will show, but one fact must be considered, and that is that when

* Paper read before the Cement Users' Association.

a block is made face down the forces exerted in the manufacture of it are at right angles to the direction in which the force is applied when the block is in the wall. This seems like a waste of opportunity for making a strong building.

I was walking around the yard of a well-known block manufacturer, and we were talking about faced blocks. During the discussion we examined some blocks which had been made in this manner three years ago, and found cracks between the facing and the remainder of the block. This man is a progressive, conscientious block maker, and I have every confidence in the blocks which he turns out, and consequently our discovery somewhat shattered my faith in faced blocks.

Third, we have the two-piece system. In this class we put all blocks in which there is no direct concrete partition between the inner and the outer wall. I can see no reason why this system should not be perfectly satisfactory as regards making a dry house. Whether they are strong enough and easy of construction, etc., is a matter outside of my province.

Fourth, I want to consider the addition of chemicals to the concrete in the course of manufacture. About a year ago I experimented extensively in adding various mixtures of chemicals to cement and making briquettes and testing them for strength. Some chemicals, of course, were very injurious and some highly advantageous.

It has always been my theory that the ideal method of waterproofing concrete was by adding a chemical during the mixing of the sand and cement, and my work was along that line. I may at this point state that I discovered a material which, when mixed with concrete, had a wonderful effect on it. The blocks containing this were white in appearance, absorbed about ½ per cent of water, and were of increased strength and density. I did not put this on the market as it increased the cost of a block a couple of cents, and my observation of the trade has been that it is after quick returns and the manufacturer does not care for anything which reduces his immediate profit, no matter how large his future returns may be.

I also experimented on the addition of various salts to cement, and found that they did not decrease the porosity to any noticeable extent, so they were of no use to me in waterproofing.

I did, however, find that they shortened the time of setting to such an extent that the results of strength tests after 48 hours showed sometimes as high as 100 per cent increased strength. Also they allowed the use of cement in temperatures several degrees below freezing.

Such salts as chloride of barium and chloride of sodium (common salt) were the best for this purpose.

One of my experiments showed after 48 hours:

Common cement, 90 pounds.
Chloride of calcium, 167 pounds.
Chloride of magnesium, 55 pounds.
Chloride of barium, 232 pounds.

The addition of these ingredients, however, increased greatly the efflorescence, as they are water soluble, and the discoloration of cement is caused by water soaking in the blocks and then coming to the surface to deposit the salts after the evaporation of the water.

This, of course, is a great disadvantage, and should be carefully guarded against by the block manufacturer in buying preparations of secret compositions.

I also would like to touch on the use of lime in mixing the blocks. The practice is becoming quite general, and I believe largely through ignorance on the part of the manufacturers. You all know that lime in the usual form is detrimental to the strength of the block, but a great many believe that the hydrated form is safe to use. This is a mistake, and should be carefully guarded against. I read an article in one of the magazines devoted to cement, recommending the use of hydrated lime for waterproofing, and was very much surprised to find such ignorance on the part of the editor.

The hydrated lime when used in the blocks is attacked by the carbonic acid in the air and changed to carbonate of lime, which has a tendency to disintegrate the blocks and deposit a white stain on the outside. Lime does undoubtedly whiten the blocks and make a better looking article, but no experienced maker will use it if he wishes to firmly establish his business.

The first quick success of the block business will be its death stroke if we are not careful, for the manufacturer has flooded the market with a lot of cheap, poor blocks, and the cry seems to be "After us the deluge." But it won't be after us, but on us.

HEAT-RESISTING VARNISHES.

THE continued efforts of certain manufacturers of varnish have been successful in producing varnishes having the property of resisting the action even of considerable heat without cracking or losing their luster—the so-called heat-resisting varnishes. These varnishes are a specialty at present, but are rapidly coming into demand. Many of our readers will therefore doubtless be glad of some information respecting the preparation of these varnishes.

As heat-resisting varnishes are required not only white but in all colors, two kinds of ground varnish are necessary, one for the white, the other for the colored variety.

For white varnish the method of preparation is as follows: Mix 10 parts by weight of bleached linseed oil, 10 of concentrated boiled linseed oil (varnish oil), and 5 of clear French resin; heat in a boiler till the water in the resin is evaporated, i. e., till the mass ceases to crackle and flows quite smoothly. Allow to cool, dilute with about 8 parts by weight of turpentine oil and let stand for about 3 or 4 days. Take 12 parts by weight of this varnish and mix with 8 parts zinc-white and 4 parts best lithopone and pass twice through a mill. Then dilute again with about 2½ parts by weight turpentine oil, when the varnish paint will be ready for use.

No driers are used for the white heat-resisting varnishes, as they are liable to darken when exposed to heat. Moreover, the addition of driers would be quite superfluous, as resin and zinc-white combine and consequently harden the varnish in a short time.

To prepare colored heat-resisting varnish, melt 6 parts by weight of clear Benguela or Kauri copal; add 7 parts bleached linseed oil and 7 of concentrated boiled linseed oil (varnish oil); dilute with 9 parts of turpentine oil and 1½ clear siccative. Select the pigments as desired. Seventeen parts of pigment are generally used with 25 of this varnish; but no definite figures can be given, as satisfactory results depend in a great measure on the quality of the paint.—Farben Zeitung.

SCIENCE NOTES.

In view of the increased facilities for transportation and the growing habit of traveling, together with the tendency to outdoor life, which seem to be characteristic to-day of all civilized nations, the next twenty-five years will probably see a return to the patient and exact studies of *the environment*, such as the chemists and physicists began, and have in some measure continued, since the middle of the nineteenth century. These studies will be directed largely to further knowledge and control of the environment, but they will not end there, for *personal hygiene*, owing to recent advances in physiology, is to-day one of the most inviting fields for work and education.

Immediately after the Franco-German war, when Germany became an empire, her leaders were far-sighted enough to see that her industrial supremacy depended upon the scientific education of her people. Acting on this principle, the government expended large sums of money in every branch of the subject. The high-grade technical schools, like those of Charlottenburg, Dresden, Hanover, Munich, Stuttgart, Darmstadt, and Carlsruhe, were given immense sums of money to increase their faculties, provide new equipment, and to erect new buildings. The largest of these, Charlottenburg, in 1900-01 enrolled 4,441 students; none of the others had less than a thousand. In addition to these high-grade schools, located at the capitals of the German states, special schools were established for each of the industries, like the weaving school of Crefeld. So thoroughly are these organized that if a valuable article bearing upon any one of their industries is printed in any language in any country it is at once translated and circulated among the technical schools. All this is under the governmental control which allows no duplication of energy nor foolish rivalry. Compare, if you will, the magnificent home of the Charlottenburg Technische Hochschule in Berlin, the most beautiful school building in Germany, or the Munich school, artistic enough to rank with the art galleries, or the royal palace in Hanover, now adapted to the use of the Hanover Technische Hochschule, or any of the other technical schools, with the modest accommodations of the universities at Berlin, Munich, or Heidelberg, or examine the budget and find what colossal sums are expended upon them and you will be convinced that Germany depends almost entirely upon her system of scientific education to win for her the industrial supremacy she so much desires.

It cannot be expected that all of the information desirable with relation to the composition and action of hydrolyzing and oxidizing enzymes will be obtainable until more is known of the proteids, to which group the ferments seem to belong, or with which they are at least closely related. Whether these enzymes are concerned with the metamorphoses involved in rendering soluble or transforming pectin, proteids, glucosides, starches, cellulose, fats, or sugars, their physiological activities are in the highest degree remarkable, and worthy of the closest study. The problems which relate to their occurrence, composition, production, and action require, however, the combined attention of physiologists and organic and physical chemists. In recent times, through the work of Brown and Morris, Fischer, Green, Prescott, Vines, Loew, Beijerinck, Newcombe, Woods, and many others, these compounds have received renewed attention. It may be that at present too many obscure phenomena are passed over with the superficial explanation that they are the result of enzyme action, and, therefore, require no further consideration. It is known that the ferments are largely concerned with the regulatory production of modification of numerous metabolic products. The activity of each enzyme is circumscribed, yet the power to do work borders upon the miraculous. It is asserted that invertin may invert 100,000 times its volume of cane sugar, and pepsin may transform 800,000 times its volume of proteids. The chemist is especially concerned with the composition and occurrence of these, but the physiologist is interested not alone in the occurrence and specific action of the enzymes, but also with the effects upon the general metabolism of the individual plant, with the methods and conditions regulating the secretion of these products, and with their vitalities or limiting external conditions. Ferments may be concerned with external cellular digestion, that is, with the solution and absorption of foodstuffs from without, thus necessitating exosmosis, or with intracellular modifications, preparatory to the direct use of the substances modified in metabolism or in translocation. Again, the ferments may be present only at a certain definite period in the life of a cell, produced, undoubtedly, by special requirements and special stimulation.

ELECTRICAL NOTES.

Consul-General Roosevelt, writing from Brussels, says that in October, 1906, there will be placed at the disposition of Belgians the Laboratory-Museum of Electricity of Brussels, which the consul-general thus describes: The establishment is built, equipped, and will be offered to the public by Robert Goldschmidt, of Brussels. The object of this philanthropic work is the development and extension of the use and application of electricity in Belgium by practical experimental instruction. The institution will contain all kinds of electrical models and appliances, which may be freely handled for study and experiment. Models and apparatus will be conveniently placed at the disposition of the public upon separate tables, and may be connected with the electric current at will. For example, a person desiring to familiarize himself with running an electric tramway, will find a complete model, about ten inches long, of an electric car, which he may freely handle for examination, and operate upon the diminutive rails. Reduced models of every part of an electric-tramway system, various dynamos, etc., are to be found in the museum. Mr. Goldschmidt hopes to extend the knowledge of the great possibilities of electricity through these practical methods. The institution is divided into four large rooms. The first is devoted to machines serving to produce phenomena due to magnetism, and to electricity by friction and chemical reaction. This room will also be devoted to the demonstration of electrical laws. A circular gallery around this room is designated as the second hall. Here are found the domain of theory and application—machines of all sorts, lamps, bells, agricultural and dairy implements, conveniently exhibited, and may be worked by simply adjusting the electric appliance supplied to each table. There will also be free telegraph, wireless telegraph, and telephone offices. The third hall is subdivided into reading rooms where the latest scientific periodicals will be on file. In the fourth hall will be found all kinds of large motors, dynamos, etc., with which the public is at liberty to study and experiment. There is no doubt that this institution, which has been planned and carried out with great forethought, will be of great benefit in affording free and practical instruction in the varied problems of electricity.

There appears to be some ground for a profitable discussion of the question whether the so-called insulating covering of moderately high-tension lines in cities might not better be abolished, says the Electrical World and Engineer. In the case of low-tension wires at voltages of 50 to 500, even a weather-proof insulation offers considerable protection against accidental short circuits, but by many it is held that there is also no question that any practicable insulation that can be placed on overhead lines of 10,000 volts and up is worthless and a waste of money. There is left a large middle range of voltages in which the advisability of an insulating covering of overhead lines is open to question. At voltages of 1,100 to 2,200, which are so common, the ordinary insulating coverings may offer a slight protection. At voltages of 4,000, 4,600, and 6,600 it is generally considered that a covering is more a matter of form than a really substantial protection. The chief use for the covering in such cases seems to be to conform to the preconceived ideas of a non-technical public and the city authorities. Against the covering of such wires it is urged that it involves unnecessary cost, that the coverings deteriorate rapidly, that they cause a feeling of false security by linemen and others, and that in some cases the insulating covering would offer enough resistance to what would otherwise be a short-circuit to prevent circuit-breakers on a high-tension line from opening when it would be best that they should. It has been fairly well proven that the best protection telephone and telegraph wires have against high-tension lines lies in the fact that the falling of such wires across a high-tension line causes such a positive and immediate short circuit that the circuit-breakers in the latter immediately open before much damage is done to the telephone or telegraph system. The insulating covering on a moderately high-tension line may delay the opening of the circuit-breaker, although a dangerous current may be flowing. This whole subject is one which deserves thoughtful consideration.

The application of gas engines to electric driving commenced in a very small way some twenty-five to twenty-eight years ago. In those days a gas engine of more than 2 or 3 horse-power was the exception, and such installations were mainly confined to lighting houses or shops. We look back to these installations with a good deal of interest, and though from our present point of view we regard them as insignificant and crude, they still did good work in their small way. They were the pioneers of what has grown to be an enormous branch of engineering, and it seems as though it were almost impossible to fix a limit to the magnitude to which gas-driven electric generation will grow in the immediate future. The great advances in the construction of a better type of dynamo very soon began to show the necessity of improving the driving capabilities of gas engines, both with respect to power and regularity. The improvement in the dynamo, however, frequently landed the gas-engine makers into trouble in the early days. Installations which would have passed muster with the crude old-fashioned dyna-

mos were not satisfactory with more efficient machines; the lights driven by them would show every impulse given by the engine, and it became obvious that considerable changes were necessary in the engines, leading ultimately to the high-speed, heavily-flywheeled, special electric-lighting gas engine. The demands of electrical engineers for the required steadiness for all kinds of continuous-current driving are amply met by these single-cylinder Otto cycle, heavily-flywheeled engines both as regards steadiness of light or running a number of units in parallel. A very large number of such plants have been installed, some of them having been in satisfactory regular use for many years.

ENGINEERING NOTES.

Experiments have shown that as the load comes on, a belt on the tight side stretches more than the slack side contracts, the result being that the sum of the tensions increases, thus bringing a greater pressure on the bearings. This is probably due to the variation in the modulus of elasticity as effected by the element of time. If the belt was non-elastic as on a chain drive, the pressure would increase directly as the load, while if the belt were perfectly elastic and could stretch and contract instantly, the pressure would remain constant.

The type of gas engine most suitable for central station work is, in the author's opinion, the vertical, with three or four cylinders, the dynamo or alternator being direct coupled to the shaft. Such a plant takes up little space, as compared with a horizontal engine, and compares generally very favorably with a steam plant. With this type of plant great cyclic regularity is obtained, and an immunity from vibration. The exhaust from an engine with several cylinders, and governed by throttling a constant mixture, is much more silent than that of a single cylinder engine governing on the hit-and-miss principle.

When concrete was first made rather dry mixtures were almost always specified, as laboratory tests indicated that they would give better results than wet ones. Actual practices, however, showed that the thorough mixing and ramming, required to develop these higher results, are difficult to secure in construction work. In the field, the best results are obtained with a mixture wet enough to quake decidedly after moderate ramming. In the United States, the tendency is undoubtedly toward extreme wetness, largely because of the advantages of wet mixtures in reinforced concrete and in works where impermeability is desired. But for other purposes, a mixture is preferable which requires considerable ramming to make it quake and which, therefore, is susceptible of some consolidation after placing. "Drowning" seriously injures the better class of cements, and, for this reason, the use of more water than is necessary to plasticity is to be avoided.

During the past decade the great bulk of scientific thought, as applied to the disposal of sewage, together, as a natural sequence, with the generally recognized practice of the engineering operations involved, has been diverted almost wholly to the development of bacterial systems of purification. It is not intended, within the scope of the present article, to trace through the history of the beginnings and subsequent development of that interesting field of bacteriological knowledge which has led up to the present position of the problem of sewage disposal, but rather to notice recent developments in connection with the practical application of bacteriological processes to the every day treatment of a town's sewage. Although the necessary presence of minute life for bringing about putrefactive and fermentation changes had been long recognized, and the cultivation of low organisms on a large scale for purposes of purification had been seriously proposed, it was not until the Massachusetts State Board of Health, in 1887, commenced their well-known experiments on the purification of sewage and water, and subsequently issued their valuable Reports, that the foundations of modern bacterial processes can be said to have been laid.

A new blast-furnace plant will in the future be equipped with just one steam blowing engine for starting the blast furnaces (unless gas producers should be installed), while the rest of the blowing engines will be operated by gas engines. The quantity of blast required will be 90 cubic feet per minute per ton of pig iron produced, or for 800 tons, $800 \times 90 = 72{,}000$ cubic feet of blast air per minute. Assuming that all the necessary blast be furnished by gas blowing engines, the latter will normally have to compress the air to about 15 to 18 pounds per square inch; but as it will be occasionally necessary to blow against a pressure of 30 pounds per square inch, the gas blowing engines must be large enough to do this work. Figuring on a maximum pressure of about 30 pounds per square inch, the work necessary to compress 100 cubic feet of air against this pressure for adiabatic compression will amount to 8.65 horse-power theoretical, or nearly 10 brake horse-power in the gas engine. As 72,000 cubic feet per minute have to be compressed, 7,200 brake horse-power in gas engines must be provided. The engines would, under these conditions, operate under full load. The heat consumption, as stated before, will be less than 9,000 B. T. U. per hour per brake horse-power. Actual tests on a double-acting tandem Cockerill gas engine show a heat consumption of 8,880 B. T. U. per hour per brake horse-power; but assuming 9,000 B. T. U. per hour per brake horse-power-hour will require $9{,}000 \div 90 = 100$ cubic feet of gas, and 7,200 brake horse-power in blowing engines will therefore require 720,000 cubic feet of gas per hour.

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